12-4-2009

Ex. 281-US-400

Dudley W. Reiser
R2 Resource Consultants

Ex. 281-US-400
BEFORE THE OFFICE OF ADMINISTRATIVE HEARINGS
STATE OF OREGON
for the
WATER RESOURCES DEPARTMENT

In the Matter of the Determination of the Relative Rights of the Waters of the Klamath River, a Tributary of the Pacific Ocean

Cynthia L. Barrett, Trustee of Sydney's 1995 Irrevocable Trust, uta 12/27/95; Elaine G. Kerns, Sydney K. Giacomini and E. Martin Kerns, as Initial Trustees of the Elaine G. Kerns 1992 Trust uta 1/24/92; Mathis Family Trust; ~~WaterWatch of Oregon, Inc.~~; Roger Nicholson; Richard Nicholson; AgriWater, LLC; Maxine Kizer; Ambrose McAuliffe; Susan McAuliffe; Kenneth L. Tuttle and Karen L. Tuttle dba Double K Ranch; ~~Dave Wood~~; ~~Kenneth Zamzow~~; Nicholson Investments, LLC; William S. Nicholson; John B. Owens; Kenneth Owens;

AFFIDAVIT AND DIRECT TESTIMONY OF DUDLEY W. REISER, Ph.D.

Case No. 281

Claims: 668, 669, 670, and that Portion of Claim 612 pertaining to the Wood River[1]

Contests: 2730, 2733, 2735, 2736, 2738, 2739, 2740, 2743, 2744, 2745, ~~3016, 3067, 3068, 3069~~[2], 3314[3], 3370, 3371, 3372, 3929, 3930, 3931, 4002, 4058, 4059, 4060

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[1] Claimant Klamath Tribes filed a notice withdrawing limited parts of its water rights claim. *See* KLAMATH TRIBES' NOTICE OF WITHDRAWAL OF STRUCTURAL HABITAT MAINTENANCE CLAIMS dated July 5, 2005.

[2] WaterWatch of Oregon, Inc.'s contests 3016, 3067, 3068, and 3069 were dismissed. ORDER DISMISSING WATERWATCH OF OREGON, INC.'S CONTESTS, May 20, 2003.

[3] William Bryant voluntarily withdrew from Contest 3314 on October 31, 2003. Dave Wood voluntarily withdrew from Contests 3314 on October 26, 2004. Change of Title Interest for Contests 3314 and 3370-3372 from Roger Nicholson Cattle Co. to AgriWater, LLC (2/4/05). Change of Title Interest for Contests 3314 and 3370-3372 from Dorothy Nicholson Trust and Lloyd Nicholson Trust to Roger and Richard Nicholson (2/4/05). Change of Title Interest for Contest 3314 from Kenneth Hufford, Leslie Hufford, and Hart Estate Investments to Jerry and Linda Neff (2/11/05). Change of Title Interest for Contest 3314 from William and Ethel Rust to David Cowan (3/9/05). Change of Title Interest for Contest 3314 from Walter Seput to Wayne James, Jr. (5/2/05). Change of Title Interest for Contests 3314 and 3370-3372 from Jim McAuliffe, McAuliffe Ranches, and Joe McAuliffe Co. to Dwight and Helen Mebane (7/8/05). Change of Title Interest for Contests 3314 and 3370-3372 from Anita Nicholson to Nicholson Investments, LLC (7/8/05). Change of portion of Title Interest for Contests 3314 and 3370-3372 from Dwight and Helen Mebane to Sevenmile Creek Ranch, LLC (8/15/05). Kenneth Zamzow voluntarily withdrew from Contests 3314 and 3370-3372 on September 2, 2005. William Knudtsen voluntarily withdrew from Contest 3314 on September 13, 2005. Change of Ownership filed for Contest 3314 reflecting that William V. Hill is deceased and his ownership rights transferred to Lillian M. Hill (6/15/06). Sevenmile Creek Ranch, LLC voluntarily withdrew from Contests 3314 and 3370-3372 on March 1, 2007. Franklin Lockwood Barnes, Jr. and Jane M. Barnes voluntarily withdrew from Contests 3314 and 3370-3372 on April 6, 2007. Mary Jane Danforth voluntarily withdrew from Contests 3314 and 3370-3372 on June 19, 2008. Change of Title Interest for Contests 3314 from Robert Bartell to Michael LaGrande (1/9/2009).

William L. Brewer; Mary Jane Danforth; ~~Jane M. Barnes; Franklin Lockwood Barnes, Jr.~~; Jacob D. Wood; Elmore E. Nicholson; Mary Ann Nicholson; Gerald H. Hawkins; Hawkins Cattle Co.; Owens & Hawkins; Harlow Ranch; Terry M. Bengard; Tom Bengard; Dwight T. Mebane; Helen Mebane; ~~Sevenmile Creek Ranch, LLC~~; James G. Wayne, Jr.; Clifford Rabe; Tom Griffith; William Gallagher; Thomas William Mallams; River Springs Ranch; Pierre A. Kern Trust; ~~William V. Hill~~; Lillian M. Hill; Carolyn Obenchain; Lon Brooks; Newman Enterprise; ~~William C. Knudtsen~~; Wayne Jacobs; Margaret Jacobs; Michael LaGrande; Rodney Z. James; Hilda Francis for Francis Loving Trust; David M. Cowan; James R. Goold for Tillie Goold Trust; Duane F. Martin; Modoc Point Irrigation District; Peter M. Bourdet; Vincent Briggs; J.T. Ranch Co.; Tom Bentley; Thomas Stephens; John Briggs; ~~William Bryant~~; Peggy Marenco; Jerry L. Neff & Linda R. Neff;

Contestants

vs.

United States, Bureau of Indian Affairs, as Trustee on behalf of the Klamath Tribes;

Claimant/Contestant, and

The Klamath Tribes;

Claimant/Contestant.

CONTENTS

I. EXPERTISE AND BACKGROUND DR. DUDLEY W. REISER

1. Please state your name and occupation.

My name is Dudley W. Reiser. I am the President of and a senior fisheries scientist with the company R2 Resource Consultants, Inc. (R2) of Redmond, Washington. R2 specializes in environmental and engineering consulting with a special focus on fish and aquatic ecology including invertebrates (both in rivers and lakes), instream flow assessments, habitat assessments, fisheries engineering, and habitat restoration. The company also provides technical expertise to clients relative to issues involving the federal Endangered Species Act (ESA).

2. Have you provided a current resume or *curriculum vitae* (CV)?

Yes. Attached to and in support of my testimony here I have provided Ex. 281-US-401. Ex. 281-US-401 is a copy of my most recent CV that details my education, professional experience, and all publications and papers I have presented throughout my career as a fish biologist.

3. Please describe your educational background.

I received a Ph.D. degree in Forestry, Wildlife and Range Sciences (major in fishery resources) from the University of Idaho in 1981, a Masters of Science degree from the University of Wyoming in Water Resources in 1976, and a Bachelor of Arts degree in Zoology from Miami University in Oxford, Ohio in 1972. Briefly my coursework included classes in fishery management, ichthyology, fish culture and disease, aquatic ecology, limnology, water quality, hydrology, aquatic entomology, statistics, and a variety of other related courses.

My master's and doctoral research were focused on flow needs of various fish life history stage components, and both involved extensive field and laboratory studies. The title of my

Ph.D. dissertation is "Effects of Streamflow Reduction, Flow Fluctuation, and Flow Cessation on Salmonid Embryo Incubation and Fry Quality." My master's thesis is titled "The Determination of Physical and Hydraulic Preferences of Brown and Brook Trout in the Selection of Spawning Locations." As part of both studies, I collected extensive physical and hydraulic measurements over areas used by salmonids for spawning.

4. Please describe generally your work experience since you received your Ph.D.

From 1980 to the present I have been involved in environmental consulting focusing on aquatic ecosystems, and in particular fish ecology and habitat requirements. Over my career, I have been employed by a number of large consulting and engineering firms including Camp Dresser and McKee (Denver) (1980-1982); Bechtel Corporation (California) (1982-1987); EA Engineering, Science and Technology (California/Washington) (1987-1992; Vice President); and R2 Resource Consultants, Inc. (Washington) (1992-present; President). In my capacity as a fish biologist, I have worked on a variety of streams, rivers and lakes throughout the Pacific coastal states (Washington, Oregon, California, Alaska) and Rocky Mountain states (Wyoming, Idaho, Montana, Colorado, Nevada, New Mexico). I have also worked on streams and rivers in a number of other states, including Massachusetts, Maine, Connecticut, New York, Vermont, Texas, Tennessee, and North Carolina.

5. Have you published in your field of expertise?

Yes. I have published articles in a number of scientific journals including Transactions of the American Fisheries Society, the North American Journal of Fisheries Management, Progressive Fish Culturist, Fisheries, Rivers – Studies in the Science, Environmental Policy and Law of Instream Flow, Regulated Rivers, Research and Management, Environmental Toxicology and Chemistry, and Hydroecologie Appliquee. I have also published chapters in eight books. A complete list of my publications is provided in my CV which is attached as Ex. 281-US-401.

6. In addition to your publications, have you written any other scientific papers or reports?

Yes. As outlined in my CV, Ex. 281-US-401, I have authored or co-authored over 100 technical reports or scientific papers related to fisheries, instream flows, and aquatic ecosystems. Of these, many were related to projects on which I was working. Some were made publicly available while others were for litigation and not publicly released. The publicly available reports are described in my CV, Ex. 281-US-401.

7. Have you made oral presentations at technical meetings and symposia?

Yes. As outlined in my CV, Ex. 281-US-401 I have made over 75 technical presentations at a variety of scientific conferences, technical meetings, and symposia.

8. Please describe your current position with R2 Resource Consultants.

I am the co-founder and president of R2 Resource Consultants (hereinafter "R2"). I am also a Senior Fisheries Scientist for R2. As president of R2, I am responsible for delegating responsibilities and assignments to a team of aquatic and fisheries scientists and water resource engineers, and overseeing their work. Since 1992, R2's staff of scientists and engineers have conducted, under my supervision, a variety of fisheries and aquatic studies and prepared designs related to management and restoration of aquatic ecosystems and support facilities that have included:

- Fish studies focused on evaluating species composition, population abundance, and population characteristics;

- Instream flow evaluations to support fish and aquatic life needs;
- Threatened and endangered species investigations and analysis;
- Aquatic invertebrate sampling and analysis;
- Ecological and fish population modeling:
- Flushing flow and sediment transport studies;
- Water quality monitoring and modeling;
- Water resources and hydrological investigations;
- Fish passage evaluations including barrier analysis;
- Fish passage concept development, cost estimating, and facilities design;
- Channel and habitat restoration, including culvert replacement for fish passage;
- Wetland and riparian ecological studies and habitat assessments; and
- Application of geographic information systems (GIS).

As a Senior Fisheries Scientist, I often lead and manage technical studies focused on fisheries and aquatic resources, especially as they may be affected by water resource and land-use impacts.

9. Please describe the types of technical studies you have worked on or are currently working on.

Since the completion of my doctoral research that involved defining spawning and egg incubation flow needs of anadromous salmonids, I have conducted numerous studies and published manuscripts related to determining instream flow needs and assessing effects of flow regulation on aquatic biota. I have been involved in instream flow projects in Washington, Oregon, Alaska, California, Colorado, Idaho, Maine, Montana, New York, Vermont, and Wyoming, and have applied a variety of different instream flow methods, including the U.S. Fish and Wildlife Service's (USFWS) Instream Flow Incremental Methodology, coupled with the Physical Habitat Simulation models (IFIM/PHABSIM), the Tennant method (also known as Montana method), the Tessman method, the Wetted Perimeter (WP) method, the Trout Cover Rating (TCR) method, the R-2 Cross Method, and the Oregon Method.

In addition to directing and managing studies for the Klamath Basin Adjudication, I am also directing instream flow studies on the Sultan River in Washington as part of hydroelectric relicensing studies for the Henry M. Jackson Hydroelectric Project, and serving as Technical Lead for instream flow studies on a large mining project in Alaska. The Upper Klamath Basin work on behalf of the United States has included defining instream flow needs for fish within major streams and tributaries of the Williamson River, Wood River, Sprague River, and Sycan River. I also recently served as project manager for completing a technical review and analysis of the North Coast Instream Flow Policy for the California State Water Resources Control Board and the Pit 1 Hydroelectric Project whitewater boating flow study in California which focused on evaluating impacts of pulse flow releases on fish and aquatic biota. I also recently managed two large-scale instream flow projects for the federal government. The first of these was for the Bureau of Indian Affairs related to the Snake River Basin Adjudication, the second for the U.S. Forest Service involving a national technical support contract for which I participated in instream flow studies associated with hydroelectric projects in Alaska, California, and North Carolina. Other instream flow studies that I have directed include those on the Lostine River and Tualatin River in Oregon, the Clark Fork, Madison and the Missouri rivers in Montana; and Ward Creek and Whitman Creek in Alaska.

In addition, I have directed numerous studies focused on determining fish population abundance and dynamics in streams, rivers, and lakes. In doing so, I have applied a variety of fish sampling techniques including snorkeling, electrofishing, seining, trap/gill netting, pop-nets, cast nets, trammel nets, ichthyoplankton sampling, and others. These types of studies have most recently included fish studies conducted for the City of Kent, Washington (urban streams), General Electric (Housatonic River, Massachusetts), Seattle Public Utilities (Lake Chester Morse and Cedar River watershed, Washington), J.L. Storedahl Company (East Fork Lewis River and series of adjoining ponds, Washington), Ketchikan Public Utilities (Alaska), and the U.S. Fish and Wildlife Service (Coeur d'Alene basin and St. Regis River, Idaho).

10. Have you otherwise been recognized for your expertise?

Yes. In 1999, I was appointed by Governor Gary Locke to Washington's Independent Science Panel, which is focused on ESA and species recovery efforts statewide; I was re-appointed to this panel by Governor Gregoire in 2005. I have also been certified by the American Fisheries Society (AFS) as a Fisheries Scientist since 1981 (certification number 1447), and was re-certified in 2002 (certification number 2463), and have been an active AFS member for over 20 years.

11. Have you previously provided expert testimony?

Yes. I have provided testimony at trial and at hearings. I have also provided evidentiary declarations via deposition and affidavit. A list of cases in which I have provided testimony and or evidentiary declarations is as follows:

- Clark County, Washington, Public Land Use Hearings regarding Daybreak Mining and Habitat Enhancement, Case No. REZ98-011, CUP20004-00002 (provided testimony regarding potential mining impacts on anadromous salmonids in the East Fork Lewis River, Washington) on behalf of the J.L. Storedahl Company (2004);

- United States of America vs. ASARCO Inc. et al., Case No. 96-0122-N-EJL and Case No. 91-9342-N-EJL (District of Idaho) (provided testimony regarding losses of habitat and fish populations resulting from long term mining impacts on the South Fork Coeur d'Alene River, Idaho, on behalf of the U.S. Fish and Wildlife Service (1999 and 2001));
- State of Montana vs. Atlantic Richfield Company, No. CF-83-317-HLN-PGH (District of Montana) (provided testimony regarding losses of habitat and fish populations resulting from long term mining impacts on the Clark Fork River, Montana on behalf of Atlantic Richfield Company (1996 and 1997));
- Snake River Basin Adjudication, Case No. 39576 (Twin Falls District Court, Idaho) (provided declaration regarding instream flow needs for fish species found in the Snake River Basin, Idaho on behalf of the Bureau of Indian Affairs (1998, 1999));
- Klamath Basin Adjudication (before the Oregon Office of Administrative Hearings and the Oregon Water Resources Department) (provided declarations regarding 1) the basis of the lake level claims submitted by the Bureau of Indian Affairs, 2) the importance of habitats located beyond the original Klamath Indian Reservation boundaries in fulfilling the life cycle needs of fish species, and 3) the validity of the lake level-habitat-water quality process used for defining the lake level claims (1997 and 2006);
- Puget Sound Energy, Inc. – Federal Energy Regulatory Commission (White River Project No. 2494-002) (provided declaration regarding flow and habitat issues in support of Puget's request for a license order stay (1998)); and
- California State Water Resources Control Board (provided testimony regarding factors influencing current distributions and abundance of fish within the Sacramento and San Joaquin river deltas on behalf of the California Urban Water Agencies regarding proposed Salinity standards for San Francisco Bay–Delta (1995).

12. Have you previously been qualified as an expert witness in other proceedings?

Yes, I have been qualified as an expert witness on Water and Fisheries Resources –Fish Biology and Fish Environment in the trials conducted in the U.S. District Courts including United States of America vs. ASARCO Inc. et al. (Case No. 96-0122-N-EJL and Case No. 91-9342-N-EJL) (District of Idaho, Boise, Idaho) and State of Montana vs. Atlantic Richfield Company (No. CF-83-317-HLN-PGH) (District of Montana, Great Falls, Montana).

13. When did you become involved in the Klamath Basin Adjudication and what has been your role?

I first became involved with the Klamath Basin Adjudication in 1990, when I was working for EA Engineering Science and Technology (EA). Then, the Bureau of Indian Affairs (BIA) had engaged EA to conduct technical studies to assist with quantifying instream flow needs of streams within the Upper Klamath Basin. I was the project director. In 1992, I left EA and co-founded R2, but continued to work with EA and remained as the principal investigator on the Upper Klamath Basin project.

As the principal investigator for this work, I have been responsible for organizing, implementing and managing the large-scale investigation focused on quantifying instream flows necessary to provide for a healthy and productive habitat for the Klamath Tribes' treaty fish species in the streams and rivers of the Upper Klamath Basin. These instream flow claims are divided into two components: the Physical Habitat Claims and the Riparian Habitat Claims (further described in Section II). Briefly, by "Physical Habitat" we refer to and mean the water environment in a stream that fish physically live in, whereas by "Riparian Habitat," we refer to and mean the streamside vegetative environment that surrounds a stream. Overall, the Physical Habitat Claim work has involved the collection and analysis of data from all major streams and tributaries within the Williamson River subbasin, the Wood River subbasin, the Sycan River subbasin, and the Sprague River subbasin. Representative types of data that have been collected on these systems have included data for instream flow assessments, habitat characterizations, fish utilization, invertebrate composition, and water quantity and quality.

14. What is the result of your investigations in the Klamath Basin?

As a result of my investigations in the Upper Klamath Basin, I have been able to form a sufficient basis to make recommendations for the flows necessary for the Wood River subbasin (Claims 668 through 670) to provide a healthy and productive fish habitat. From 1990-1999, studies were conducted under my direction to quantify and prepare the Physical Habitat Claims, which were filed by the BIA as trustee on behalf of the Klamath Tribes in 1997 and amended in 1999. Since 1999, I, and others under my direction, have continued to analyze existing information and collect and analyze supplemental data that would further our understanding of the flows necessary to provide for healthy and productive habitats for the target fish species. During this time, I worked closely with Mr. Michael Ramey, a senior hydrologic engineer in our office, who was responsible for compiling and completing a technical review of all hydrologic information and data available for streams in the Wood River subbasin. Ultimately, as a result of this collaborative work, I have been able to form a sufficient basis for updating the Physical Habitat Claims for the Wood River subbasin (Claims 668 through 670). The 1999 Physical Habitat Claims form the upper limit for these updated claims. In addition, I have worked with Dr. David Chapin in preparing and updating of the Riparian Habitat Claims.

15. What is the purpose of your testimony?

My testimony is directed toward describing the need and basis for the Physical Habitat Claims and the quantity of water claimed. My primary focus was on the habitat needs including stream flows of the Klamath Tribes' treaty fish species. The stream flow needs of treaty non-fish species, which also require sufficient stream flow in the Upper Klamath Basin, is presented in the testimony of other witnesses including Dr. David Chapin, Mr. Perry Chooktoot, and Mr. Jeff Mitchell.

The development of the Physical Habitat Claims reflects two decades of scientific work. This work involved a team of technical specialists working under my direction or supervision, including fisheries biologists, aquatic ecologists, riparian ecologists, aquatic entomologists, water quality specialists, hydrologists and hydraulic engineers (lead by Mr. Ramey; see Ex. 281-US-200, Affidavit and Direct Testimony of Mr. Michael Ramey (Mr. Ramey Direct Testimony)) and biometricians. Similarly, the Riparian Habitat Claim work, led by Dr. David Chapin, also involved a team of specialists. See Ex. 281-US-300, Affidavit and Direct Testimony of Dr. David Chapin (Dr. Chapin Direct Testimony).

The purpose of my testimony is threefold. First, my testimony provides an overview and chronology of the development of the Physical Habitat Claims. Second, my testimony describes the methods used, the rationale applied, and process followed to develop Physical Habitat Claims to provide healthy and productive habitats for the Klamath Tribes' treaty fish species, based on analysis of the habitat and flow needs of target fish species. Third, my testimony describes the updated Physical Habitat Claims for each claim reach (Claims 668 through 670) by calendar month based on all information developed and collected over the last two decades. This information includes that additional information and analysis developed since 1999 when the amended claims were filed. Where appropriate, I refer to various reports, publications, data summaries, maps, photographs and other materials that I (or others under my direction) developed and/or relied upon in updating the Physical Habitat Claims. The rationale behind and methodology used to form the basis for the Physical Habitat Claims has generally remained consistent throughout the claims development process; however, many of the updated Physical Habitat Claim flows presented here are lower than the 1999 flows, but never higher. Any reduction is the result of our collection and analysis of data since 1999. Finally, my testimony also briefly addresses the Riparian Habitat Claims as an important component of a healthy and productive fish habitat.

16. Please summarize your basic conclusions.

My overall conclusion is that the instream flows reflected in the Physical Habitat Claims are sufficient to provide healthy and productive habitats in streams within the Wood River subbasin at levels that meet, but do not exceed, the spatial needs of the target fish species. The flows also take into consideration the role that water temperature plays, the importance of invertebrates, and the overall significance of riparian habitat. I further conclude that such flows, when coupled with the Riparian Habitat Claims, described in Dr. Chapin Direct Testimony, will promote the restoration and/or maintenance of viable and self-renewing populations at levels from which tribal harvest can occur. Physical Habitat and Riparian Habitat flows represent necessary and essential components for achieving healthy and productive habitat; however, other factors may limit the abundance of target fish species. Further, although the focus of my work was on developing Physical Habitat Claims that would provide healthy and productive fish habitat, the methods employed and supplemental data collected were aimed to ensure that no more was claimed than that necessary. However, as I note in my testimony, such flows, while representing a necessary and essential component for achieving healthy and productive habitat, are not sufficient alone to provide a healthy and productive fish habitat. This can only occur when such flows occur in parallel with actions that address other factors that are continuing to limit the population abundance of the target fish species as described further in this testimony. Finally, the updated Physical Habitat Claims tend to be conservative, meaning they are generally on the lower side of the range of flows I would consider necessary to provide healthy and productive habitats.

17. Dr. Reiser, you have used several terms that need defining. First, please describe what you mean by "treaty species" and "target fish species."

In general, the term "treaty species" in this testimony refers to all species of plants and animals that are subject to the Klamath Tribes' treaty-protected harvest rights, and that were historically, or may be presently or in the future, hunted, fished, trapped, gathered, or otherwise harvested by the Tribes. For this testimony, I focus on the fish species that have been historically fished by the Klamath Tribes, or may be presently or in the future, which are referred to here as "treaty fish species."

The number of overall treaty fish species on the former Klamath Reservation is quite large; therefore, to focus our habitat analysis for target fish species, we selected certain of those fish species as "target fish species" for in-depth study. For purposes of this testimony, "target fish species," which form the basis for quantification of the Tribal instream flow Physical Habitat Claims, refers to the following fish species: redband trout, Bull Trout, Lost River sucker, Shortnose sucker, Klamath largescale sucker, and Chinook salmon.

18. Please describe what you mean by a "healthy and productive habitat."

To understand the phrase "healthy and productive habitat," it is instructive to look at each of the words separately. "Habitat" is an objective term used in biological analyses that refers to the environment in which a species exists throughout its lifecycle, as well as those surrounding environments that provide material or support to the environment in which the species exists. For example, the fish habitat includes both the instream environment that provides living space, food, and protection from predation, as well as the bordering stream environment that contributes both food and nutrients and provides shade.

The terms "healthy" and "productive" are more subjective because these terms seek to describe the quality and quantity of habitat necessary for a species to exist in a sound state and to propagate. "Healthy" is best understood via the analogy used by the Administrative Law Judge to the provision of health care for a person wherein the primary question is "[w]hat are the basic health care needs of [a] person that will not only keep him alive but allow him to be healthy?" Amended Order on Motions for Ruling on Legal Issues, February 13, 2007, Case 281 p. 16. As such, a healthy habitat must have sufficient water to provide an environment wherein the needs of the target fish species are met in a way that allows the species to exist in a stable, sound state rather than a minimal state or just barely hanging on from year to year. Similarly, "productive" habitat must have sufficient water to support a species' ability to reproduce and provide a robust population that can withstand impacts from both environmental and man-made factors.

19. What is your definition of a "healthy and productive habitat?"

My definition of "healthy and productive habitat" for fish is: a stream environment that (i) allows the target fish species to exist in all lifecycles in a stable and sound state; (ii) supports the target fish species' ability to reproduce on a long-term basis; and (iii) provides a robust fish population that can withstand harvest of the species and impacts to its habitat, such as from drought, land use practices, and other events.

20. Are there other terms in your testimony that require definition?

Yes. For convenience, I have included a Glossary that defines various scientific and technical terms, and acronyms, as an Appendix (see Appendix A) at the end of my testimony.

21. Do you reference and rely upon reference material in your testimony?

Yes. Throughout my written testimony, I make several references to government reports or published or copyrighted articles or books to support my testimony. A listing of all publications, reports, books, and other technical materials to which I reference in my testimony is attached as an Appendix (see Appendix B) at the end of my testimony.

22. How are exhibits presented in your testimony?

Throughout my written testimony, I make reference to material in support of my testimony designated as exhibits, which are generally designated in the form "281-US-4XX." Copies of these materials are being provided with my testimony. A complete list of the exhibits that are described and presented through my testimony is attached as an Appendix (see Appendix C) at the end of my testimony.

II. THE PHYSICAL HABITAT AND RIPARIAN HABITAT COMPONENTS OF THE INSTREAM FLOW CLAIMS

23. As an initial matter, please explain the basis of the Physical Habitat Claims and the Riparian Habitat Claims.

The Physical Habitat Claims are concerned with the living space provided by streamflow that is needed to support the life history functions of fish and other aquatic organisms. These claims are specifically for flows necessary to provide healthy and productive habitats in streams within the Wood River subbasin at levels that meet, but do not exceed, the spatial needs of the target fish species.

The Riparian Habitat Claims are concerned with the land-stream interface area bordering each side of the stream and the quantity of flow needed to maintain a healthy and functioning riparian zone. This interface area, referred to as the riparian zone, has special ecological significance relative to streams, rivers, and, most importantly, fish habitat. From a fish habitat perspective, the riparian zone provides a number of components necessary to the overall fish habitat: (i) shade that serves to keep water temperatures cool; (ii) a supply of wood to the stream that provides shelter to fish and habitat for fish supporting organisms; (iii) a source of nutrients to the stream in the form of leaf fall; and iv) a source of food organisms for fish resulting from insects dropping into the water from the vegetation. These flows also help in part to maintain the channel structure, flush and transport sediments, and create new habitat structures within the channel.

My testimony will primarily focus on the presentation of and support for the Physical Habitat Claims. Dr. Chapin Direct Testimony provides the presentation of and support for the Riparian Habitat Claims. However, to be clear, a healthy and productive riparian zone is necessary to a healthy and productive fish habitat in the streams of the Upper Klamath Basin.

24. How do the Physical Habitat Claims relate to the water rights claimed by the BIA as trustee on behalf of the Klamath Tribes (Tribal water rights)?

Basically, the Tribal water rights require the provision of flows necessary to provide healthy and productive habitats within the streams of the Upper Klamath Basin. This means, in simple terms, fish of a riverine system need flowing water in order to propagate and properly develop. More specifically, a sufficient quantity of flow to meet the requirements of each lifestage of a fish species is fundamental to a healthy and productive habitat. This is because fish living in flowing waters require adequate volumes of flow to meet all aspects of their life history or lifestages, from spawning, to egg incubation, fry, juvenile, and adulthood. Furthermore, maintaining a connection between different habitat types within the watershed is likewise important to the propagation of healthy, abundant populations of fish. For example, spawning habitat may be in different locations than the habitat where fish feed and grow. Flows must therefore be sufficient to allow fish to migrate between and within these areas.

Flowing water provides the basic habitat building block of living space for riverine fish. Fish distinguish the "livability" of flowing water based in part on water velocity and water depth. Water velocities above or below a certain velocity range are unattractive and even intolerable to fish. Likewise, water depths below a certain depth range, or that are too shallow, are also unattractive and are avoided by fish. Combinations of these velocity and depth parameters across a stream create a mosaic of habitat conditions used by different species and life stages.

In addition, a fish species' substrate (materials on the bottom of a stream such as gravel, sand, etc.) and cover (protective shelter) needs are impacted by flow and further refine the quality and usability of the living space. Substrates of varying sizes and shapes provide important spawning, rearing, and holding habitats. Protective structural cover in the form of undercut banks, overhanging vegetation, instream boulders/cobbles, and large woody debris add to the quality of the fish habitat. Further, good water quality conditions (e.g., suitable water temperatures, dissolved oxygen concentrations, turbidities, etc.) and an abundant food supply are conducive to the propagation of fish; both similarly depend on many of the same flow-related physical, hydraulic, and chemical conditions.

Flowing water also provides a mechanism for food delivery to drift-feeding fish such as trout. Terrestrial insects that fall into the stream and benthic macroinvertebrates (small organisms that live on or within the bottom of the stream) are swept downstream by the current and preyed upon by fish. Other species, such as suckers, are generally bottom feeders, relying on algae and insects attached to the substrate. Larval suckers observed within the Wood River are believed to feed nearly exclusively on suspended organic material that is readily available during springtime high flow events.

Finally, flowing water is also critical to fish migrations. The temperature and chemical constituents of the flowing water serve as guides to migratory fish returning to natal waters. The volume of water must be sufficient to provide adequate depths for fish passage, particularly over shallow or obstructed areas.

25. You have thus far discussed fish species generally. Please discuss the fish species that were the focus of your work in the Upper Klamath Basin.

Because of the diversity of habitat conditions and widely ranging topography that create climatic variability and complex hydrology, the streams and rivers within the Upper Klamath Basin support a variety of fish species. Those fish species known to exist in the streams of the Upper Klamath Basin are included in OWRD Ex. 2, pp 4 through 5. The Klamath Tribes historically utilized many of the different fish species found in the Upper Klamath Basin for subsistence and ceremonial purposes. See Ex. 281-US-411. Today, the abundance of most if not all of these species has been severely reduced in comparison to fish abundances reported in and throughout the 19th century and the early half of the 20th century (Nehlsen et al. 1991).

The Physical Habitat Claims were focused on six target fish species which are species of fish of particular importance to the Klamath Tribes and of particular interest to state (Oregon Department of Fish and Wildlife (ODFW)) and federal agencies (U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS)) for their sport fish value (e.g., redband trout), listing status under the Federal Endangered Species Act (ESA) (e.g., bull trout, Lost River sucker, shortnose sucker), and historical presence within the upper Klamath River Basin (e.g., Chinook salmon). These target fish species are but six of several other treaty fish species of the Klamath Tribes that are dependent on the stream flows of the Upper Klamath Basin.

I am generally familiar with the habits and needs of each of the target fish species as well as other fish species occurring in the Upper Klamath Basin. See OWRD Ex. 2, pp 4 through 5.

The six target fish species include the following three salmonid species (members of the trout family), and three sucker species (scientific names provided in parentheses):

Redband trout	(*Oncorhynchus mykiss newberrii*)
Bull trout	(*Salvelinus confluentus)*
Chinook salmon	(*Oncorhynchus tshawytscha) (Spring and Fall Chinook)*
Lost River sucker	(*Deltistes luxatus)*
Shortnose sucker	(*Chasmistes brevirostris)*
Klamath largescale sucker	(*Catostomus snyderi)*

The Physical Habitat Claims addressed in this testimony were directed toward providing no more than the flows necessary to provide a healthy and productive habitat for these target fish species. I believe that these same flows will also generally provide healthy and productive habitats for other native fish species in the Upper Klamath Basin.

26. What is the major objective of the instream flow claims?

The Physical Habitat and Riparian Habitat Claims focus on establishing the amount of flow necessary in streams of the Upper Klamath Basin on a monthly basis to provide for productive, healthy habitats for target fish species subject to the Klamath Tribes' hunting, fishing, trapping, and gathering rights. As previously mentioned, the updated Physical Habitat Claims are centered on six target fish species that historically were or currently are important to the Klamath Tribes.

27. What, if any, is the relationship between the Physical Habitat and Riparian Habitat flows?

The Physical Habitat flows work with the Riparian Habitat flows to provide healthy and productive habitat for the target fish species. The Administrative Law Judge (ALJ) made an analogy in an earlier ruling in this case between the health of fish habitat and the health of a human patient (*see* Amended Order on Motions for Ruling on Legal Issues, February 13, 2007, Case 281 p. 16); the analogy is a good one to illustrate the important connection between the Physical Habitat component and the Riparian Habitat component of a stream ecosystem.

The analogy to a human patient centers on the fact that a patient is dependant on many systems working together. Each human system has independent and sometimes overlapping needs of blood, oxygen, and nutrients; however, meeting minimal blood, oxygen, and nutrients needs of just one system without consideration to other body systems would compromise the health of the patient. For example, without a healthy cardiovascular system, a patient will not thrive, survive, or be healthy despite otherwise intact respiratory, nervous, and skeletal systems. Another analogy would be with respect to the health of a human being as influenced by the health of his/her environment. Clearly, human populations subjected to conditions of insufficient air, water and food, in conjunction with an environment that provides limited physical space to inhabit, would not survive and propagate as well as populations living in areas with clean air and water, abundant food, and plenty of living space.

Likewise, healthy fish habitat in a stream consists of many components including the water environment that fish physically live in (Physical Habitat) and the surrounding streamside and vegetative environment (Riparian Habitat). The two habitats together provide the fundamental elements for fish survival. For example, a fish needs a specific range of flow conditions in order to complete essential life history functions including migration, spawning, feeding and growing, but a fish also needs the riparian environment to provide crucial stream components, such as stream energy (e.g., food, material, nutrients), structure (e.g., erosion control, large woody debris, riffle/run/pool habitat variety), and protection (e.g., protection from predators, substantial water temperature controlling stream shade). While the physical and riparian habitats have at times, different streamflow needs, both habitats depend on each other and on sufficient streamflow to create healthy fish habitat. Thus, the provision of flows to meet the needs of one type of habitat without providing for the other would affect the health of the aquatic ecosystem and limit the productivity of the fish populations. For these reasons, the Physical Habitat and Riparian Habitat flows are essential ingredients for providing and protecting important in-channel and out-of-channel processes, and for promoting healthy and productive fish habitats that lead to the propagation of target fish species for harvest by the Klamath Tribes.

28. What has been the extent of your work associated with the Tribal instream flow claims?

My work has involved consideration of all aspects of the Tribal instream flow claims in this case. However, as a fish biologist my work has primarily centered on developing the basis for and analysis of the Physical Habitat Claims. The Physical Habitat Claims were developed and updated over a period of 18 years extending from 1990 to present. Speaking on the broadest of scales, the work associated with the development of these claims involved research, field data collection, scientific analysis, review, critique, and professional judgment.

Between 1990 and 1999, I directed and/or participated in the conduct of research, fieldwork, and analysis to develop and support the Physical Habitat and Riparian Habitat Claims and amendments filed by the BIA. The majority of fieldwork and data analysis leading up to the 1999 claims was completed between 1990 and 1994 and the flow recommendations and ensuing claims were developed after that. Since 1999, we have continued to evaluate and update the Physical Habitat Claims and the Riparian Habitat Claims. This ongoing work has included the re-evaluation of existing data, the collection and analysis of additional field data and flow data, and the evaluation of other hydrologic data and basin hydrology, particularly that hydrology information and analysis developed by the Oregon Department of Water Resources (OWRD). The purpose of continuing this work has been to incorporate additional information into our analysis that would assist us in defining the flows necessary to provide a healthy and productive habitat.

29. What is the result of your work over the past two decades?

Based on the continued collection of data, analysis of existing and additional data, and evaluation of necessary flows, we have updated the Physical Habitat and Riparian Habitat Claims from the 1999 values. The updated Physical Habitat Claims presented in this testimony reflect additional information and analysis. It is my understanding that the 1999 claims must serve as an upper limit to the instream flow claims. Therefore, the updated Physical Habitat and Riparian Habitat Claims are either lower than the 1999 claims or equal to them.

30. What are the updated Physical Habitat Claims?

The updated Physical Habitat Claims are presented in Section IX. For each claim reach in this case (Claims 668 through 670), flows are specified for each of the twelve (12) months of the calendar year. The Physical Habitat Claims often have two components. The first component of the Physical Habitat Claims is for the target fish species presently occurring in the Upper Klamath Basin (otherwise referred to as "present target fish species"). These are the flows that should be put in place immediately to provide for the health and productivity of fish habitat for species occurring in the Upper Klamath Basin today. The second component of the Physical Habitat Claims is for all target fish species of the Upper Klamath Basin, including Chinook salmon (otherwise referred to as "all target fish species"). These flow claims are conditional and to be given effect only upon re-introduction of anadromous fish to the Upper Klamath Basin.

Finally, the support and updated flows for the companion Riparian Habitat Claims are presented through Dr. Chapin Direct Testimony that is filed simultaneously with my testimony. I have reviewed the updated Riparian Habitat Claims and am of the opinion that the claims are necessary to support the health and productivity of the physical habitat occupied by fish in the streams of the Wood River subbasin. It is my opinion that the Physical Habitat and Riparian Habitat flows are those needed to provide healthy and productive habitats for the Klamath Tribes' target fish species.

III. THE UPPER KLAMATH BASIN AND THE WOOD RIVER

31. Are you familiar with the Upper Klamath Basin and the streams and rivers in the basin and its subbasins?

Yes. I am very familiar with the Upper Klamath Basin region, particularly the streams and rivers of the basin. My familiarity comes from many sources. As I have described, my work in the Upper Klamath Basin has spanned two decades. In support of my ability to form my expert opinion and recommendations, I have reviewed and studied topographic, biologic, hydrologic, and geologic data and reports, as well as public documents, maps, and references that characterized the physical setting of and the fish and streams in the basin. In addition, I have sought out and drawn upon the experience of both scientific and lay persons familiar with the basin. Further, I have firsthand familiarity with the basin and its streams from the many visits I have made and directed in the basin. Finally, I personally, and through the direction of those under my supervision, participated in the site selection and stream data collection activities on all of the instream flow study sites in the Upper Klamath Basin, including field data collection, stream fish surveys, and stream invertebrate sampling.

32. Please describe the physical boundaries of the Upper Klamath Basin which have been the focus of your work.

The Upper Klamath Basin is located in south-central Oregon, covering an area of approximately 3,810 square miles. For the purpose of this testimony, the Upper Klamath Basin includes all drainages extending from the eastern slope of the Cascade Range east to the Gearhart Mountains, which drain south and west, eventually discharging into Upper Klamath Lake (Figure III-1). Upper Klamath Lake is the largest lake in the basin, with a surface area of 100-140 square miles, depending on its stage (Gannett et al. 2007). The Link River flows out of the lower end of

Upper Klamath Lake and after 3.2 miles becomes the Klamath River below Klamath Falls. The Klamath River runs through southeastern Oregon and into northern California, ultimately emptying in to the Pacific Ocean in northern California.

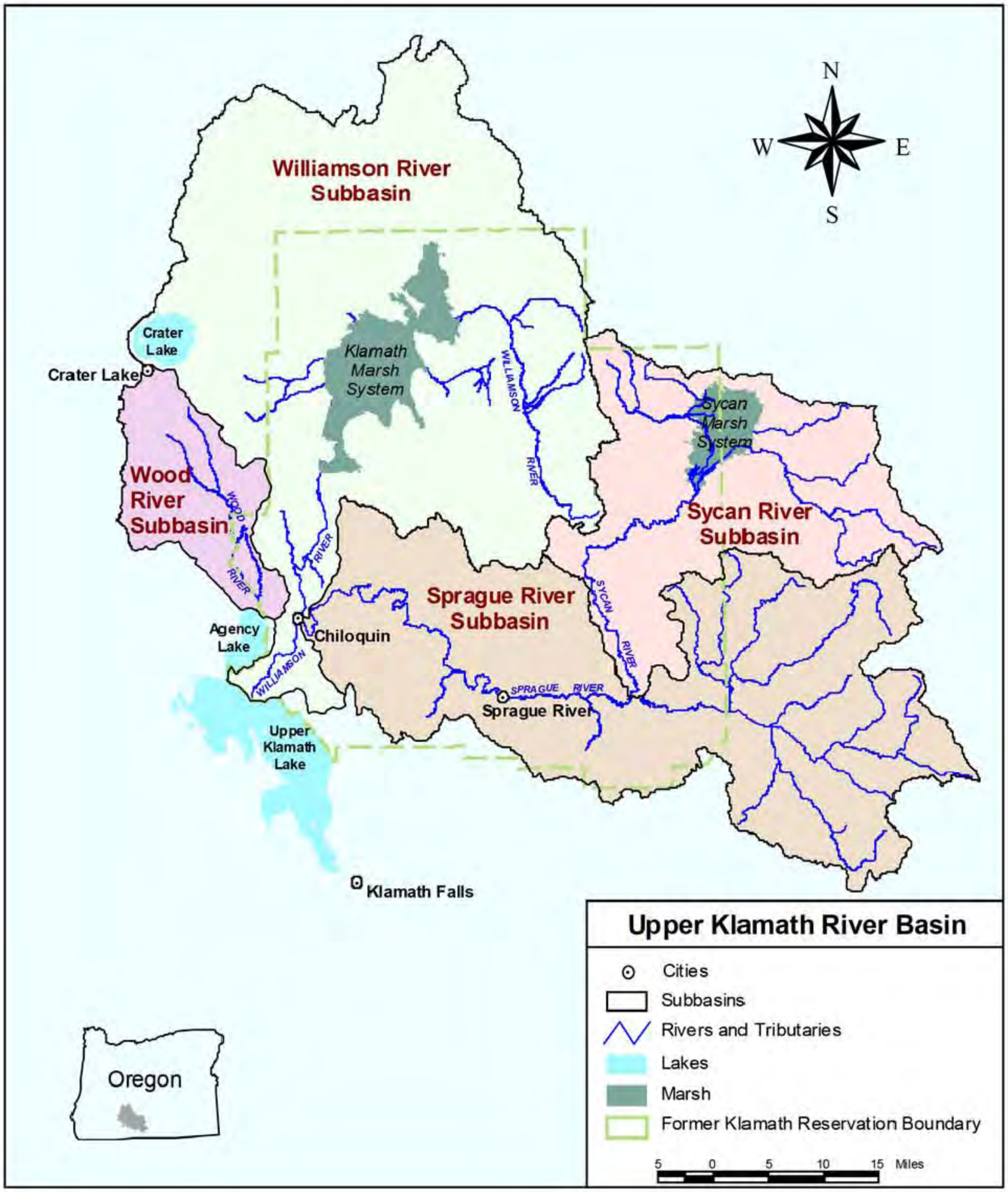

Figure III-1. Map of the Upper Klamath Basin, Oregon depicting the Wood, Williamson, Sycan and Sprague River Subbasins.

33. What are the important physical features of the Upper Klamath Basin?

In terms of physical features, the western end of the Upper Klamath Basin, stretching along the eastern slope of the Cascade Mountains, typically consists of high, steeply sloped terrain underlain by highly permeable soils and basaltic formations. The basin has been dominated by volcanic activity and active faulting that has served to shape and control many of its broad valleys. This activity has created many springs that emanate through the volcanic rock and porous materials and contribute to flows in streams. A number of springs drain the eastern slope of Mount Mazama, a dormant volcano whose caldera created Crater Lake, contributing substantial flow in the Wood and Williamson rivers. The eastern portion of the basin is also mountainous, and includes the headwaters of the Sprague, Sycan, and Williamson rivers. Elevations within the Upper Klamath Basin in Oregon range from 9,182 feet at Mount Thiesen in the Cascade Range to as low as 4,139 feet at Upper Klamath Lake. The typical ridge elevations for the northern and eastern portions of the basin range from 5,500 to 7,000 feet, respectively. The lower portions of the basin consist of gentle slopes and poorly draining soils typified by marshlands when not under cultivation.

34. Please describe the principle drainage systems of the Upper Klamath Basin.

Principal streams in the Upper Klamath Basin which are the focus of my testimony include the Williamson River, the Wood River, the Sprague River, and the Sycan River. The Williamson River is a 1,420 square mile subbasin draining the northern and central parts of the basin. The Wood River originates at a series of large springs north of Upper Klamath Lake, and drains an area of 219 square miles. The Sprague River (a tributary to the Williamson River) is a 1,021 square mile subbasin draining part of the eastern side of the basin. The Sycan River (a tributary to the Sprague River) is a subbasin that drains an additional 559 square miles in the northeastern part of the basin. The combined Williamson River, Wood River, Sprague River, and Sycan River subbasins have a drainage area of approximately 3,000 square miles and constitute 79 percent of the total drainage area of the Upper Klamath Basin, and about one-half of the inflow to Upper Klamath Lake (Risley and Laenen 1999). In addition, the Upper Basin contains two remarkable and large marsh areas: the Klamath Marsh (approximately 232 square miles) in the Williamson River subbasin, and the Sycan Marsh (approximately 39 square miles) in the northernmost area of the Sycan River subbasin.

35. Please describe the land forms and landscapes of the Upper Klamath Basin.

Approximately 80 percent of the Upper Klamath Basin is forested (Gannett et al. 2007). Eastern upland forests are predominately ponderosa pine, with some areas of fir. Lower elevation upland forests are largely made up of lodge-pole pine stands. Forests in the Cascade Range are composed primarily of stands of mountain hemlock and red fir (Gannett et al. 2007). Stream valleys and the broad, sediment-filled structural basins generally have extensive marsh land, the most remarkable of which are Sycan Marsh and Klamath Marsh. At lower elevations in such areas as the Wood River and Sprague River valleys, the subbasins have been mostly converted to agricultural land.

36. Please describe the fish species in these systems.

As noted above, the main target fish species which have been the focus of our studies and analysis since 1990 included redband trout, bull trout, Lost River sucker, shortnose sucker, Klamath largescale sucker, and Chinook salmon. These are native fish species of the basins, meaning their occurrence was via natural processes rather than human introduction. Redband trout, bull trout, Lost River sucker, shortnose sucker, and Klamath largescale sucker are found in the Upper Klamath Basin today. Chinook salmon and steelhead trout (*O. mykiss*), an anadromous[1] relative of the redband trout, were both historically present in the Upper Klamath Basin (see Affidavit and Direct Testimony of Dr. Richard Hart at questions 19 through 47 and 54 through 61 (Ex. 281-US-100) (Dr. Hart Direct Testimony)), but were blocked by the construction of Copco Dam on the Klamath River.

I am also aware of and familiar with other reported fish species in the streams within the basin including a number of introduced species such as brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and brown bullhead (*Ictalurus nebulosus*).

37. Have you been involved in studies of these species?

Yes. In addition to having completed fish surveys in many of the streams and rivers within the Upper Klamath Basin and its subbasins, I have been involved in numerous technical meetings with many researchers and scientists in the region where the life habits and population characteristics of these species have been discussed. Most recently I served as an invited

[1] Anadromous fish spawn in freshwater, with resulting progeny migrating downstream to the ocean where they spend several years before returning as adults to freshwater to complete the life cycle.

member of an Independent Scientific Review Panel convened by the USFWS that completed a 5 Year Review of the two endangered sucker species noted above. I have also kept up to date on much of the peer-reviewed literature pertaining to the species I have described.

38. What are the general life history characteristics of the target fish species?

I provided a description of the life history characteristics of each of the target fish species in a previous report (Reiser et al. 2001) a copy of which I provide as Ex. 281-US-402. Additional life history information can be found as part of ORWD Ex. 2, pages 5 through 15, and in Moyle (2002), Wydoski and Whitney (2003), and the National Research Council (2004 and 2008). As well, general life cycle diagrams of each target fish species are presented in Section IV of my direct testimony (see Figures IV-5 through IV-10). A specific life history table that depicts the timing of spawning, egg incubation, fry and juvenile rearing, and adult holding and migration of target fish species for the Wood River subbasin will be more specifically discussed in Section VII of my direct testimony (see Figure VII-5).

39. You mentioned Chinook salmon and steelhead trout as being historically present in the Upper Klamath Basin. Were there other species that were also historically present?

Yes. Regarding Chinook and steelhead, substantial historical evidence shows that both Chinook salmon and steelhead trout historically used the streams of the Upper Klamath Basin for spawning and for juvenile rearing (Hamilton et al. 2005; Fortune et al. 1966). Dr. Hart Direct Testimony at questions 19 through 47 and 54 through 61, along with the publications and materials relied upon by him, provides additional corroboration of the historical presence of anadromous species in the Upper Klamath Basin. In addition, Pacific lamprey, another anadromous species, reportedly used the streams of the Upper Klamath Basin (Hamilton et al. 2005). At the turn of the Twentieth Century, dams were built on the Klamath River. The consequence of the construction of these dams was to physically block the anadromous species from migrating upstream and into streams of the Upper Klamath Basin for spawning and rearing. Thus, anadromous species do not currently utilize the Upper Klamath Basin.

40. As to the selection of target fish species, does this mean that the other species are not important or were not considered in developing the Physical Habitat Claims?

No. Although the focus on the claims may have been on certain species, development of the claims considered all of the species known to be present or historically present and with a likelihood of return to the basin in the foreseeable future (e.g., Chinook salmon). As described above, OWRD Ex. 2, pp 4 through 5is a complete list of fish species know to exist in the Upper Klamath Basin.

41. What are the fundamental needs of fish?

Fundamentally, fish need water to live. Fish possess gills for respiration which can only function when the fish is totally submerged in water. In general, the amount of water in a stream defines the physical boundaries within which animals that are completely dependent on water are located. It is only within these physical boundaries that these animals such as fish are able to complete all of their life history functions necessary to sustain their populations. In simple terms, the quantity of water flowing in a stream defines the outer limit of the possible habitat for a fish. Thus, if the amount of water falls below levels that allow for successful reproduction, protection of fry, rearing of juveniles, migration of adults, or other life history functions, the overall health of a fish population will be directly and adversely affected (e.g., the population will decline, population viability will be reduced, etc).

42. If there is sufficient water to keep a fish submerged, is that enough to allow it to survive?

No. Just as it is not sufficient for humans to survive by just being given enough air to breathe, it is not sufficient to simply keep a fish wetted or submerged with water to allow it to survive. Many flow-related factors influence the survival of an individual fish (e.g., food and waste product elimination), and many more flow related factors influence the survival of a fish population (e.g., those that relate to reproduction, growth and maturation). While flowing water is certainly necessary for survival of fish in a riverine system, flowing water must be provided in sufficient quantity and of a sufficient quality (e.g., velocity, depth, temperature, dissolved oxygen, etc.) to promote and sustain fish populations. In addition, the timing and frequency of flows is important since they impact lifestage functions such as the migration patterns of fish, spawning, and juvenile and adult rearing.

Similarly, and separately, flows of sufficient quantity, quality, and frequency are likewise needed to maintain important riparian habitats and promote channel and habitat diversity. As described earlier, these latter flows are the focus of the Riparian Habitat Claims described in Dr. Chapin Direct Testimony at question 25. The riparian habitats surrounding a stream are integral to fish habitat.

43. Did you consider the quantity, quality, timing, and frequency of flows as you developed the Physical Habitat Claims?

Yes. In the process of developing the Physical Habitat Claims, I considered these aspects of flows. I also considered other flow-related aspects such as riparian habitat (noted above), temperature, and aquatic invertebrates.

44. What is your opinion of what the Physical Habitat Claims will provide?

I believe the Physical Habitat Claims will provide healthy and productive habitats sufficient to allow the sustainability of the populations of the target fish species. In this case, the flows provided by the Physical Habitat Claims create the very basic "building" in which the fish species, and their lifestages, can reside. This physical space in a stream provided by flows is essential to a healthy and productive fish habitat. Other factors such as water quality, availability of food, availability of cover and shelter to avoid predation, and availability of suitable spawning habitat in terms of gravel quality and quantity, must also be present to provide a healthy and productive habitat in order to sustain viable fish populations. Thus, it is the physical space (provided by flows) in combination with other components that is needed to support an overall healthy and productive habitat.

45. You stated that flows are necessary to provide habitat. Is there a direct relationship between flow and the amount of habitat in a stream?

Yes. There have been hundreds of studies completed that have demonstrated habitat:flow relationships in streams. The application of the IFIM/PHABSIM methodology[2], as we used in

[2] "Physical HABitat SIMulation (PHABSIM) is part of a broad conceptual and analytical framework for addressing stream flow management issues called the Instream Flow Incremental Methodology (IFIM) (Stalnaker et al., 1995). IFIM provides a problem-solving outline for water resource issues in streams and rivers.

the Upper Klamath Basin and as I will later describe in Section VII, specifically results in the development of species and lifestage specific habitat:flow relationships. It is important to keep in mind that although direct relationships between stream habitat and flow exist, habitat:flow relationships can be complex depending on channel morphology and instream structure. In Section VII of my direct testimony, I provide an illustrative example of a habitat:flow relationship (see Figure VII-3). Also, in Section IX of my direct testimony, I provided the specific habitat:flow relationships for each of the claim reaches in the Wood River subbasin (e.g., Ex. 281-US-421 associated with Claim Reach 668).

46. You stated there is a direct relationship between flow and habitat in a stream. Is there also a direct relationship between flow and the number of fish in a stream?

Every stream has a theoretical, upper-limit carrying capacity above which no more fish can live in a stream. However, outside purely theoretical considerations, in most streams, the number of fish that live in a stream is set by a host of biotic (e.g., food availability, predation, disease) and abiotic (e.g., temperature, water quality, substrate, flow, climatic variability) factors. Under a given set of conditions, any one factor, alone or in combination with others, might mask or make unrecognizable a direct relationship between flow and population size. This is the reason that instream flow needs assessments are based on physical habitat (or indicators of such) relationships with flow, not population abundance. In my 32 years of experience in working on

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IFIM and PHABSIM were developed as aids to instream flow decision making (http://www.fort.usgs.gov/products/Publications/15000/chapter1.html). The Physical Habitat Simulation System (PHABSIM) (Milhous et al. 1989) is an integrated collection of hydraulic and microhabitat simulation models designed to quantify the amount of microhabitat available for a target species over a wide range of discharges flows (Bovee et al. 1998; http://www.fort.usgs.gov/products/Publications/3910/chapter1.html). For purposes of this testimony, I have adopted the convention of citing the primary method used in developing the Physical Habitat Claims as IFIM/PHABSIM.

instream flow projects, I have yet to encounter a situation where the relationships between flow and fish abundance have been quantifiably established so they could be used in a flow prescriptive process.

47. Are there other factors in addition to flows that influence fish abundance in streams in the Upper Klamath Basin?

A number of factors in addition to flow influence fish abundance in the streams of the Upper Klamath Basin. These factors include water quality, land-use activities (e.g., grazing), disease, invasive (introduced) species, angling, and predation. Any one or combination of factors may mask the relationship between flow and fish abundance; however, if those other factors were not influencing the fish, then flows would have a direct controlling effect on fish abundance.

48. Does this mean that flows are not important to fish abundance in the Upper Klamath Basin?

No. Flow is one of the fundamental determinants for providing healthy, sustainable populations of fish. Relationships between flow and the numbers of fish exist; however, in basins such as the Upper Klamath Basin a determinable and predictive relationship regarding abundance generally cannot be established because of the many determinants involved. Therefore, it is generally not possible to define and then rely on flow:abundance relationships when prescribing an instream flow regime for a given stream system.

49. Is it possible to determine the amount of water necessary to provide a viable and self-renewing population of target fish species that would enable the exercise of the Tribal treaty rights?

Yes. By establishing stream flows for the Upper Klamath Basin streams, the health and productivity of fish habitat can be reasonably assured to the extent that the stream flow is assured. The Physical Habitat Claims provide for the creation and/or maintenance of the living space or structure within which healthy and productive fish habitat occurs and which is essential to the development and sustainability of viable populations of the target fish species. Without the flows that provide for such habitats, the population viability of the target fish species would be at best doubtful and correspondingly, the ability of the Tribes to exercise their rights to fish would be more uncertain.

IV. PROVIDING A HEALTHY AND PRODUCTIVE HABITAT FOR TARGET FISH SPECIES

50. Dr. Reiser, you stated that the Physical Habitat Claims will provide healthy and productive habitat for target fish species. How do you define "healthy and productive habitat"?

No single quantitative measure for or scientifically recognized definition of what constitutes "healthy and productive" habitat exists. What comprises a healthy and productive habitat and whether a healthy and productive habitat exists are questions that require consideration of a multitude of factors in combination with the exercise of scientific judgment, from a biological perspective.

In a general sense, healthy and productive habitat can be defined intuitively as habitat that possesses all of the essential ecological ingredients to allow aquatic biota to properly function (i.e., they are healthy) and to reproduce in numbers that are sufficient to sustain and allow harvest of a portion of the population under varying climatological conditions (i.e., they are productive). From a water perspective, this can be more narrowly defined as habitat that is afforded the right amounts of flow (perhaps the most important ecological ingredient) at the right times to allow fish species to fulfill all life history functions (i.e., they are healthy) and to reproduce at levels that allow harvest (i.e., they are productive). In the case of streams in the Upper Klamath Basin, this means the provision of flows that not only maintain the existing quality and quantity of habitat space that fish reside in, but also over the long term promote new habitats and habitat diversity within a stream.

51. Have other scientists considered what contributes to healthy fish habitat?

Yes. There have been a number of scientists who have attempted to render some definition of what constitutes a healthy riverine ecosystem. Karr et al. (1986), for example, suggested that a biological system is healthy when its inherent potential is realized, its condition stable, its capacity for self-repair when perturbed is maintained, and minimal external support for management is needed. However, Norris and Thoms (1999) suggest Karr's definition only focuses on the aquatic biota, while ignoring the non-biological and out-of-stream components (e.g., channel form, flow regime, riparian zone, and floodplain functions). Norris and Thoms (1999) question the notion that it is possible to have healthy assemblages of biota associated with an unhealthy channel.

An expansion of Norris and Thoms' question is whether it is possible to have healthy habitat without sufficient streamflow to provide for the living spaces of fish and other aquatic biota and to maintain the form and function of the stream channel. My answer to this question is no, it is not possible to have healthy habitat without sufficient streamflow. Moreover, healthy, self-sustaining populations of fish depend on combinations of physical, chemical, and biological factors that are provided by streamflow that occur in the right proportions and at the right times, i.e., under a healthy flow regime. Determining when and how much streamflow is needed to provide healthy and productive habitats in streams within the Wood River subbasin was the focus of our field work and modeling analysis.

52. How is fish habitat related to stream productive capacity and streamflow?

To answer this question, I want to first frame the concept of healthy, productive habitat by employing a definition imparted by Levy and Slaney (1993), which coincidentally in part forms the basis behind Canada's Department of Fisheries and Oceans policy of "No Net Loss of Productive Capacity of Fish Habitat." The Levy and Slaney definition is for productive capacity which is the maximum natural ability or capacity of a habitat to support healthy fish or grow aquatic organisms upon which fish depend. Productive capacity is determined in part by flow, but also by other components such as water quality, food production capability, channel morphological characteristics including the amount of cover and shelter areas, geographic characteristics, and climate characteristics. Fish habitat represents a combination of stream productive capacity (again the natural ability of a habitat to support healthy fish or grow aquatic organisms upon which fish depend) as well as its useable area or space. In combination, these two elements define the carrying capacity of a stream, which in essence is the maximum number of fish supportable by the given set of habitat conditions. Importantly, while the amount of useable area or space will vary with the quantity of streamflow, the stream productive capacity does not necessarily vary with the quantity of streamflow; it may be controlled by one or more of the other items I mentioned above.

Shirvell (1986) demonstrated the importance of both elements (streamflow and stream productivity) to fish production and carrying capacity. Shirvell cited an example where the fish biomass in one stream changed over time even though there was no change in percent useable physical habitat as defined by streamflow. Thus, in that circumstance, factors related to productive capacity were more influential in determining fish production than the availability of space. The reverse of this is certainly true, especially in systems in which the factors that define productive capacity (e.g., water quality, food availability) are not limiting. In these instances, I would expect fish production to be more closely linked to the available livable space within a stream, and, by extension, to streamflow. Figures IV-1 and IV-2 serve to illustrate these concepts. Figure IV-1 demonstrates how the carrying capacity of a stream can vary with streamflow; more flow translates to more space that can be inhabited by fish, and hence, all things being equal, the ability to support a greater number of fish. Figure IV-2 depicts changes in carrying capacity that result from elements other than streamflow. In this case, although streamflows are the same under the three conditions portrayed (i.e., the amount of physical space is the same), a higher carrying capacity occurs as more instream cover is provided. Obviously, differing amounts of streamflow, coupled with different types and amounts of the factors that influence productive capacity will result in different carrying capacities of fish.

The Physical Habitat Claims presented today were focused primarily on providing for the spatial needs of the fish population as provided by streamflow and that are best represented in Figure IV-1; however, consideration was also given to some of the other productive capacity elements that are known to be influenced by streamflow, such as temperature, and in particular, as will be described in detail in Dr. Chapin Direct Testimony at questions 19 and 25, flows to support riparian habitat. In developing the claims, the goal was to achieve flows that would provide healthy and productive habitat sufficient to allow the Tribes to exercise their treaty fishing rights. Specific details of the overall process used for determining these flows are provided in Sections VII and VIII.

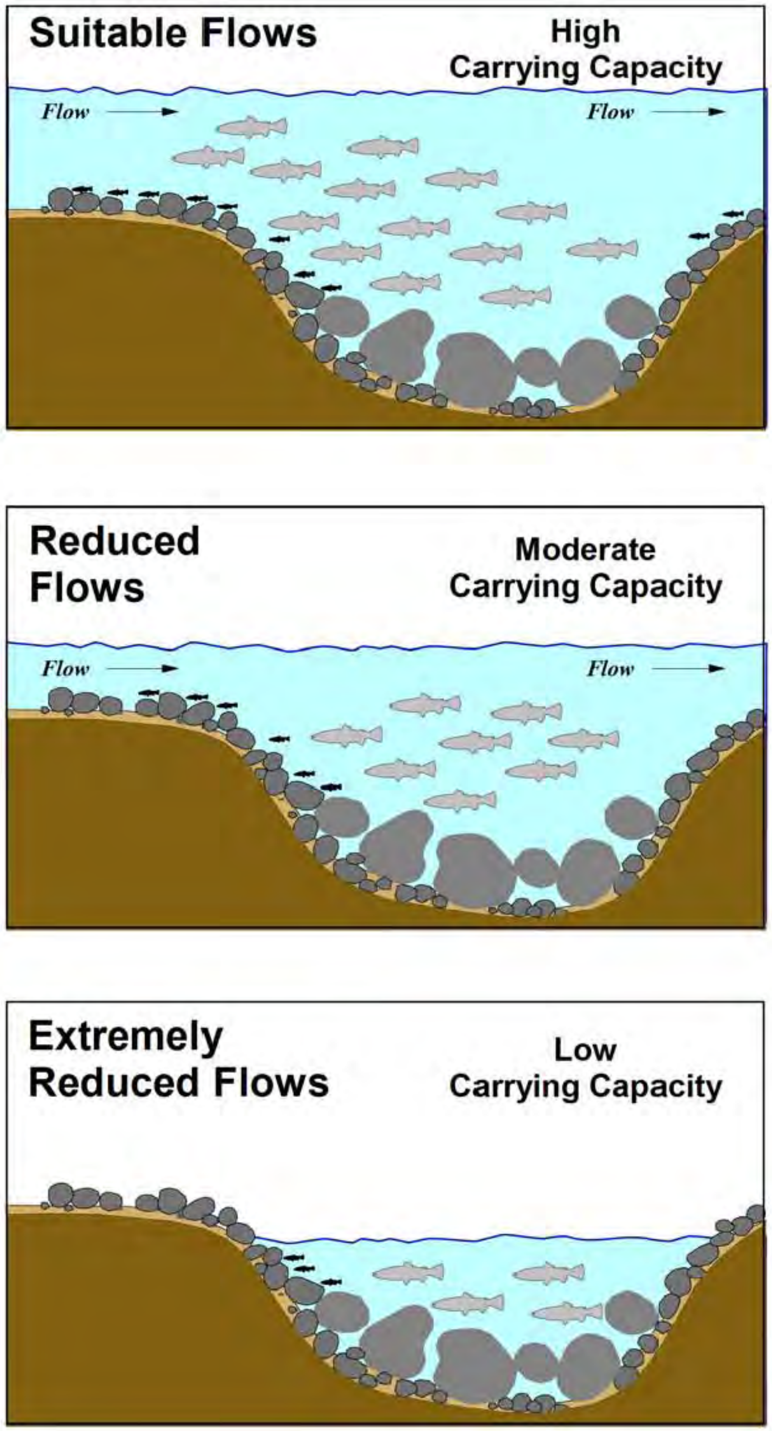


Figure IV-1. Influence of streamflow on fish carrying capacity. Under conditions of similar habitat, water quality, food availability, and instream cover, increases in flow will generally increase the carrying capacity of the stream up to some maximum level.

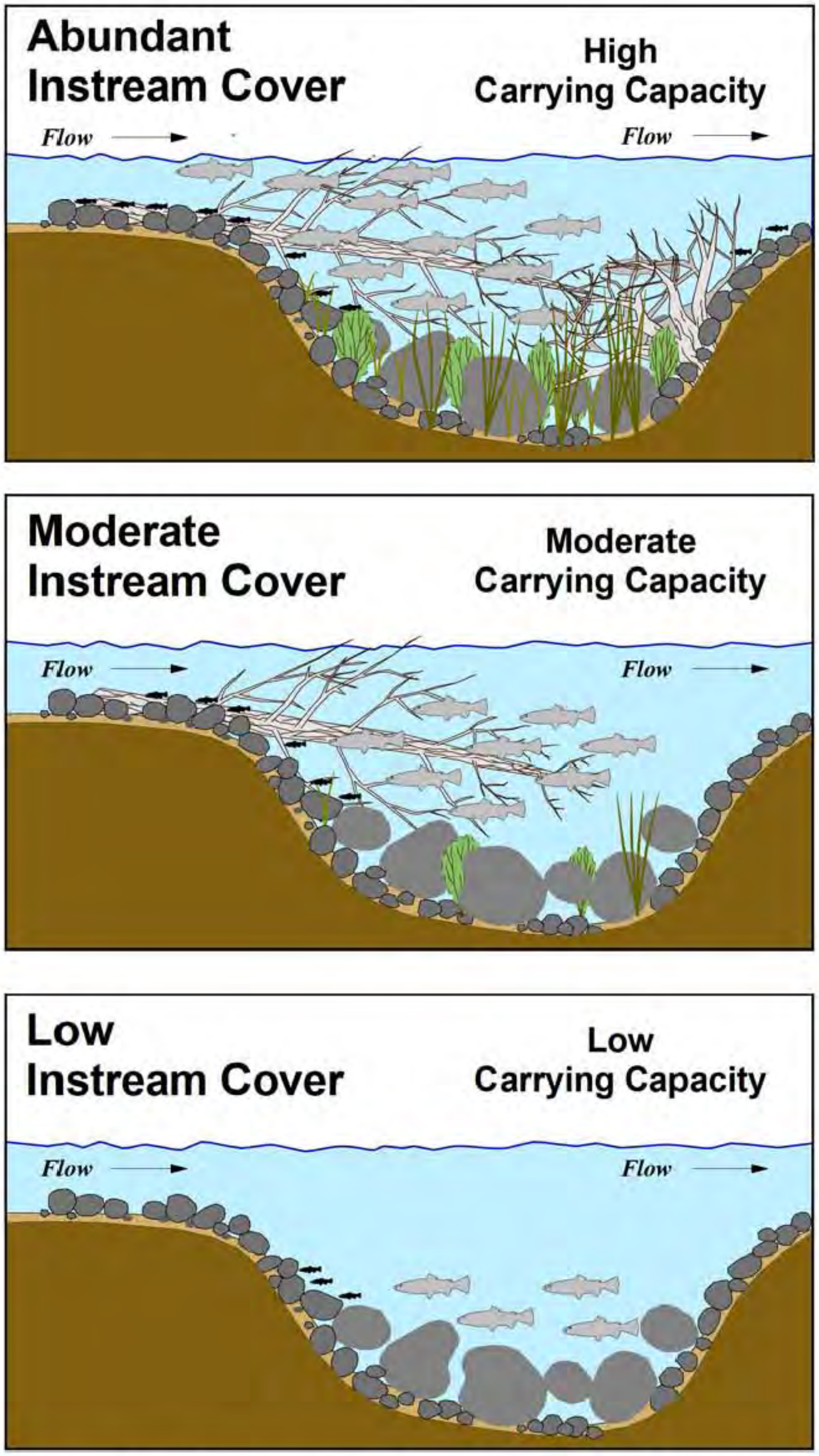


Figure IV-2. Influence of habitat components on carrying capacity. Under conditions of similar streamflow, changes in habitat structure, food availability, water quality, instream cover (this example) will generally result in changes in stream carrying capacity up to some maximum level.

53. What impacts, if any, can reduced flows have on carrying capacity?

Reductions in flow can concomitantly translate into reductions in carrying capacity, as has been demonstrated experimentally by White et al. (1981). Fewer fish can be supported due to the lower flows, and it is for this very reason that oftentimes it is the summer/fall low flow periods that actually set the carrying capacity of streams. The potential effects of flow diversions in the Upper Klamath Basin generally coincide with periods of summer/fall low flows. Since the stream is already at a relatively low flow condition in summer/fall, diversions can severely reduce the amount of space in pools, and concomitantly, the carrying capacity of the stream (e.g., Figure IV-1).

54. How do productive capacity and flow relate to streams in the Upper Klamath Basin, generally, and specifically to the Physical Habitat Claims?

Scientists have often described flows in streams in terms of natural, altered, regulated, and modified, with the last three essentially all describing conditions in which some aspect of the natural flow regime of a river has been changed by some act of manipulation by man (e.g., reduction in flows, changes in the seasonal patterns of flows, fluctuations in flows, etc.). With few exceptions, the flow regimes in most of the streams in the Upper Klamath River Basin have been altered to some degree, some quite substantially. If we start from the premise that natural flow regimes provide the maximum amount of healthy and productive habitat, the goal of establishing instream flow claims for the Upper Klamath Basin becomes one of determining at what point or threshold along a "flow alteration scale" the habitat ceases to be healthy and productive. The objective of the Physical Habitat Claims was to apply the best available science and information to identify the flow(s) just above that point, which would comprise the flows represented in the claims sought in this adjudication.

55. Can the condition of stream habitat be further classified in a way that factors in streamflow? If so, how?

Yes. Some finer definitions of the habitat:flow concept and how it relates to aquatic biota can be added by considering the following Ecological Management Classes of river regulation that have been applied elsewhere (Postel and Richter 2003):

- Class A (natural) – natural conditions (i.e., no flow regulation): negligible modification of instream and riparian habitats and biota.
- Class B (good) – largely natural with few modifications: ecosystem essentially in good state; biota largely intact.
- Class C (fair) – moderately modified: a few sensitive species may be lost; populations of some species likely to decline; tolerant or opportunistic species may become more abundant.
- Class D (poor) – largely modified (i.e., high degree of flow regulation): habitat diversity and availability have declined; mostly only tolerant species present and often diseased; population dynamics disrupted.

Conceptually under this system, the Physical Habitat Claims for the streams of the Wood River subbasin were largely targeting Class B conditions that would provide healthy and productive habitats (and corresponding carrying capacities) at levels that would allow the Tribes to exercise their fishing rights.

56. Did you consider both flow-related principles and non-flow related principles when developing the Physical Habitat Claims?

Yes. When developing the Physical Habitat Claims, I gave significant consideration to the work of Naiman and Latterell (2005) who outlined eight relatively broad principles they considered necessary to maintain robust fish communities over the long term. Dr. Naiman is currently a professor at the University of Washington College of Ocean and Fishery Sciences and has published over 200 journal articles and written and edited ten books related to aquatic ecology and watershed management. His research interests have focused on the structure and dynamics of streams and rivers, riparian vegetation, and the role of large animals in influencing system dynamics. He has also been involved in researching interactions between marine-derived nutrients and riparian vegetation, and in evaluating the environmental consequences of changing water regimes. His full vitae can be found at http://www.fish.washington.edu/people/naiman/index.html. Dr. Latterell received his Ph.D. from the University of Washington where his research focused on understanding large wood dynamics in river ecology. He has published numerous articles related to large wood, riparian and river ecology, and streamflows, and is currently a senior ecologist working for King County, Washington as part of the Watershed and Ecological Assessment Unit.

I am familiar with many of Dr. Naiman's publications and felt that his 2005 work, with Latterell, in particular aptly describes many of the key precepts related to and ingredients of healthy and productive habitats that were used in developing the Physical Habitat Claims and the Riparian Habitat Claims (see Dr. Chapin Direct Testimony at question 19). Moreover, each principle is linked to others and most are related to streamflow by varying degrees. Thus, for these reasons, I considered the Naiman-Latterell principles in developing the Physical Habitat Claims.

The Naiman and Latterell principles are as follows:

1. Habitats can be created by "keystone" species and interactions among species;
2. Productivity of aquatic and riparian habitat is interlinked by reciprocal exchanges of material;

3. The riparian zone is fish habitat;
4. Fishless headwater streams are inseparable from fish-bearing rivers downstream;
5. Fish may utilize different habitats, in different locations, and at different times in their life-cycle;
6. Habitats change over hours to centuries;
7. Fish production is dynamic due to biocomplexity, in species and in habitats; and
8. Management and conservation strategies must evolve rapidly in response to present conditions, but especially the anticipated future.

57. Please describe Naiman and Latterell's first principle, which you stated is an underpinning for a healthy and productive fish habitat.

The first principle for healthy, productive habitat is that habitats can be created by "keystone" species and interactions among species. Naiman and Latterell (2005) recognized that certain animals exert a disproportionate influence on ecosystems and considered these "keystone" species. Keystone species animals carry nutrients, energy and/or genetic materials to and between otherwise separate habitats. They can influence the structure and dynamics of receiving habitats, even if they only utilize those habitats infrequently.

Examples of keystone species that presently exist in the Wood River subbasin include the adfluvial redband trout, Lost River sucker, shortnose sucker, and Klamath largescale sucker. Although these species spend a large percentage of their lives within Upper Klamath Lake, they migrate into streams of the Wood River subbasin to spawn. Resulting juvenile fish may also use the streams to feed and grow before moving back downstream to the lake. In these cases, the physical habitats of the streams are influenced by spawning activities that include disruption of the streambed and flushing of fine sediments from the gravels. Energy transfer occurs in the form of both waste products from both the adult and juvenile fish. In addition, although the above four species are iteroparous fish, meaning they can spawn more than one time, in general, a certain percentage of adult fish die following spawning. Nevertheless, the decomposition of adult carcasses provides an important source of nutrients to the stream that can be used by other aquatic organisms as well as trees and other vegetation that comprise the riparian zone.

Further, according to Hamilton et al. (2005), and as supported by Dr. Hart Direct Testimony at questions 19 through 47 and 54 through 61, two other "keystone species" that were historically present in the Wood River subbasin are Chinook salmon and steelhead trout. Both of these species are anadromous, meaning they spend a substantial portion of their lives in saltwater where they grow and mature, and then migrate into freshwater for spawning and juvenile rearing.[1] Unlike steelhead, which is iteroparous, Chinook salmon have a life cycle of approximately five years and are semelparous, meaning that they spawn only once and afterwards die. The historical contribution of both species and in particular that of Chinook salmon to the nutrient cycle and energy transfer in streams within the Wood River subbasin was almost certainly ecologically significant given their importance in other river systems (Naiman et al. 2002).

58. Was this principle of keystone species incorporated into developing the Physical Habitat Claims?

Yes. The work to develop the Physical Habitat Claims was specifically focused on providing for the spatial and temporal habitat needs of the target fish species, which can also be considered as keystone species based on Naiman and Latterell's definition. Stated another way,

[1] Rearing is the term used by fish biologists for the period of time in which juvenile fish feed and grow. In the case of anadromous fish, the end of the juvenile rearing period culminates when the fish undergo smoltification, a process that results in physiological changes to the fish that readies them for transitioning to saltwater.

the work to develop Physical Habitat Claims was specifically focused on identifying those flows that would nurture the propagation and/or formation of healthy and productive habitats that are relied upon by the target (keystone) fish species.

59. Please describe Naiman and Latterell's second principle which you stated is an underpinning to a healthy and productive fish habitat.

The second principle for healthy, productive habitat is that the productivity of aquatic and riparian habitat is interlinked by reciprocal exchanges of material. Naiman and Latterell (2005) described this exchange linkage as a derivative of the "River Continuum" concept ("RCC") (Vannote et al. 1980), which is graphically displayed in Figure IV-3. The RCC simply states that the biological and physical conditions of any segment of a stream are influenced directly by conditions existing alongside and upstream of the segment. That is, the development of healthy and productive habitat at a given location for one or more of the target fish species is dependent on the delivery of flows of sufficient quantity and quality originating upstream, as well as energy and food inputs provided directly from the upstream and adjoining riparian zone. The RCC predicts that for natural, unperturbed stream ecosystems there is a gradient of physical conditions that determines community structure and ecological functions as the ecosystem progresses from headwaters to mouth. As the hydrologic processes, food resources, nutrient dynamics, and riparian vegetations change with the increasing stream size, the composition of fish communities and macroinvertebrate communities will change in response (Vannote et al. 1980; Cummins 1979). Studies have shown, for example, that a reduction in leaf litter and wood resulting from removal of riparian forests resulted in sharp reductions in the abundance and biomass of aquatic invertebrates, which represent one of the primary food sources of fish (Wallace et al. 1999).

60. Was Naiman and Latterell's second principle (reciprocal exchange of materials between aquatic habitats and riparian habitats) incorporated into developing the Physical Habitat Claims and the Riparian Habitat Claims?

Yes. The work to develop the Physical Habitat Claims focused on providing flows that maintain the linkages between the aquatic habitats that house the target/keystone species, and the riparian habitats that help to make them healthy and productive (via the Riparian Habitat Claims).

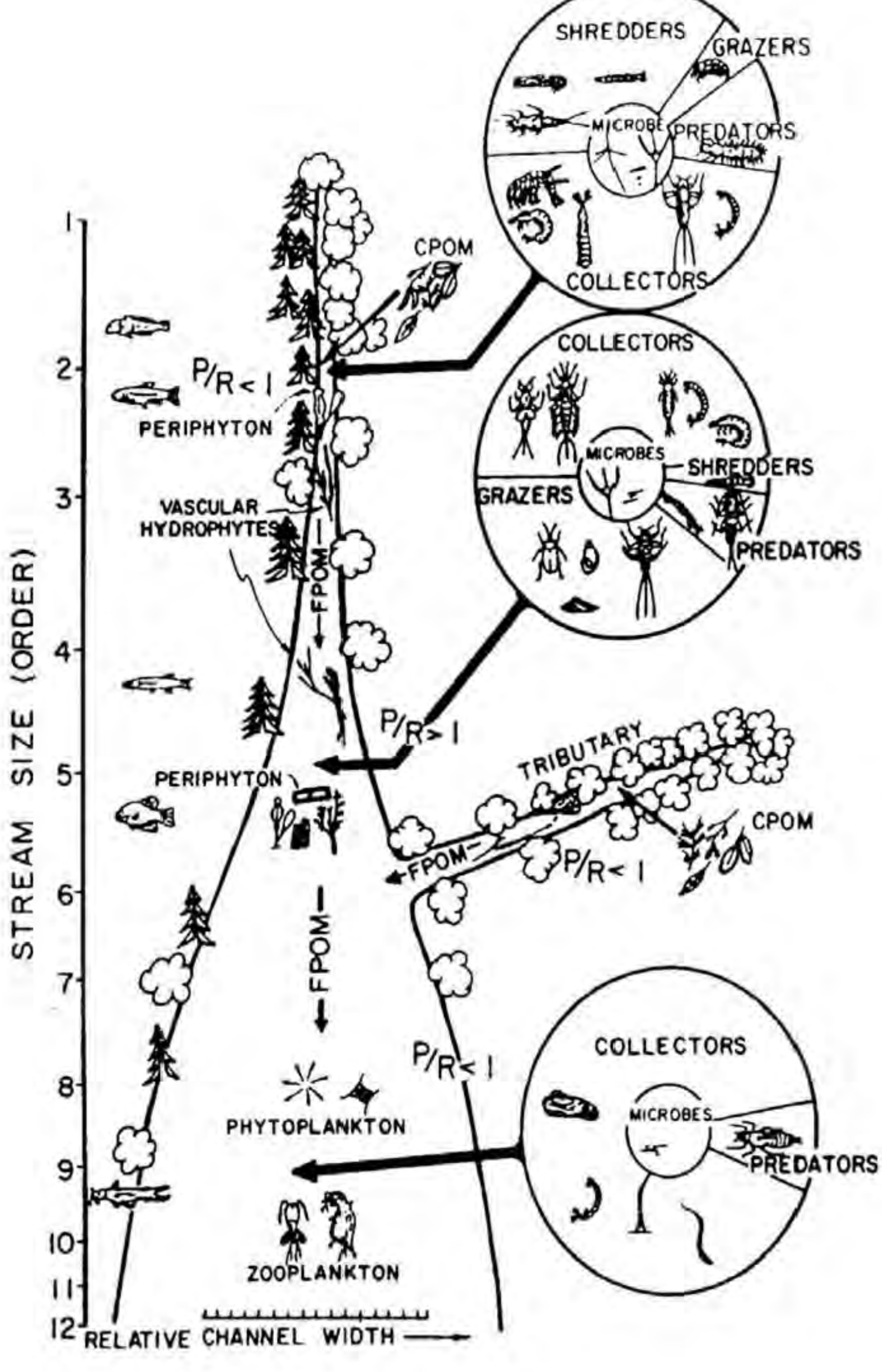


Figure IV-3. The River Continuum Concept, depicting the theoretical relationship between stream size (stream order – progresses from small streams (order 1) to larger streams (order > 1), energy inputs, and ecosystem functions (from Vannote et al. 1980).

61. Please describe Naiman and Latterell's third principle which you stated is an underpinning to a healthy and productive fish habitat.

The third principle for a healthy, productive habitat is that the riparian zone is fish habitat. This principle proffered by Naiman and Latterell (2005) is an extension of the linkage principle just noted, but serves to specifically highlight the ecological significance of the riparian zone to fish habitat. In their construct, Naiman and Latterell suggest that the consequences of large wood and food inputs on stream structure and productivity are so strong as to qualify the riparian zone as fish habitat. Naiman and Latterell (2005), Bilby and Bisson (1998), Fausch and Northcote (1992), and others have all noted the importance of large woody debris in fostering a healthy and productive aquatic ecosystem. Functionally, large woody debris has been shown to influence the shaping of channel structure and form, to facilitate the movement of particulate matter such as fine sediments, to provide habitat and a food base for macroinvertebrate communities, to create fish habitat complexity and form new habitats such as spawning areas, and to provide velocity shelters for fish during high flows, escape cover from predators, and protected feeding stations from which to forage on drifting insects. Studies have also shown that the overall densities of fish are higher in streams containing high concentrations of large woody debris (Fausch and Northcote 1992; Hicks et al. 1991), especially in the winter (Tschaplinski and Hartman 1983; Murphy et al. 1986).

The direct input of food from the riparian zone in the form of terrestrial insects (e.g., grasshoppers, crickets, beetles, flies, etc. that fall or are blown into a stream) is another reason that the riparian zone is fish habitat. As noted by Reiser and Bjornn (1979), terrestrial insects, which are important food items for salmonids may enter the stream by falling off riparian vegetation, by being blown off riparian vegetation, or by wave action that entrains some shoreline insects. Allan et al. (2003) reported that about half of the food items consumed by juvenile coho salmon in a southeast Alaska stream were comprised of insects of terrestrial origin. Wipfli (1997) measured terrestrial inputs of insects to six coastal Alaska streams and noted that food consumption by salmonids was equally split between terrestrial and aquatic insects. Wipfli (1997) concluded that terrestrially-derived insects comprised an important component of salmonid prey and that a riparian over-story with alder and denser shrub understory might increase the abundance of terrestrial invertebrates.

Importantly, the health of the riparian zone can be directly influenced by streamflow conditions. Further, such riparian zone health has a direct effect on the general health of fish populations. Figure IV-4 contains a conceptual diagram of a stream and its riparian zone under two sets of flow conditions. Under unregulated flow conditions in which normal high flow and low flow conditions occur at a natural frequency and magnitude (depicted in the upper panel of Figure IV-4), the riparian zone is healthy and diverse, and provides a variety of functions (shade, wood recruitment, cover, source of food) that serve to promote healthy and productive fish habitat and fish populations. Under regulated flow conditions, both high flow and low flow conditions can become reduced in frequency and magnitude leading to a reduction in the functionality of the riparian zone and correspondingly impact the health and productivity of fish habitat and fish populations.

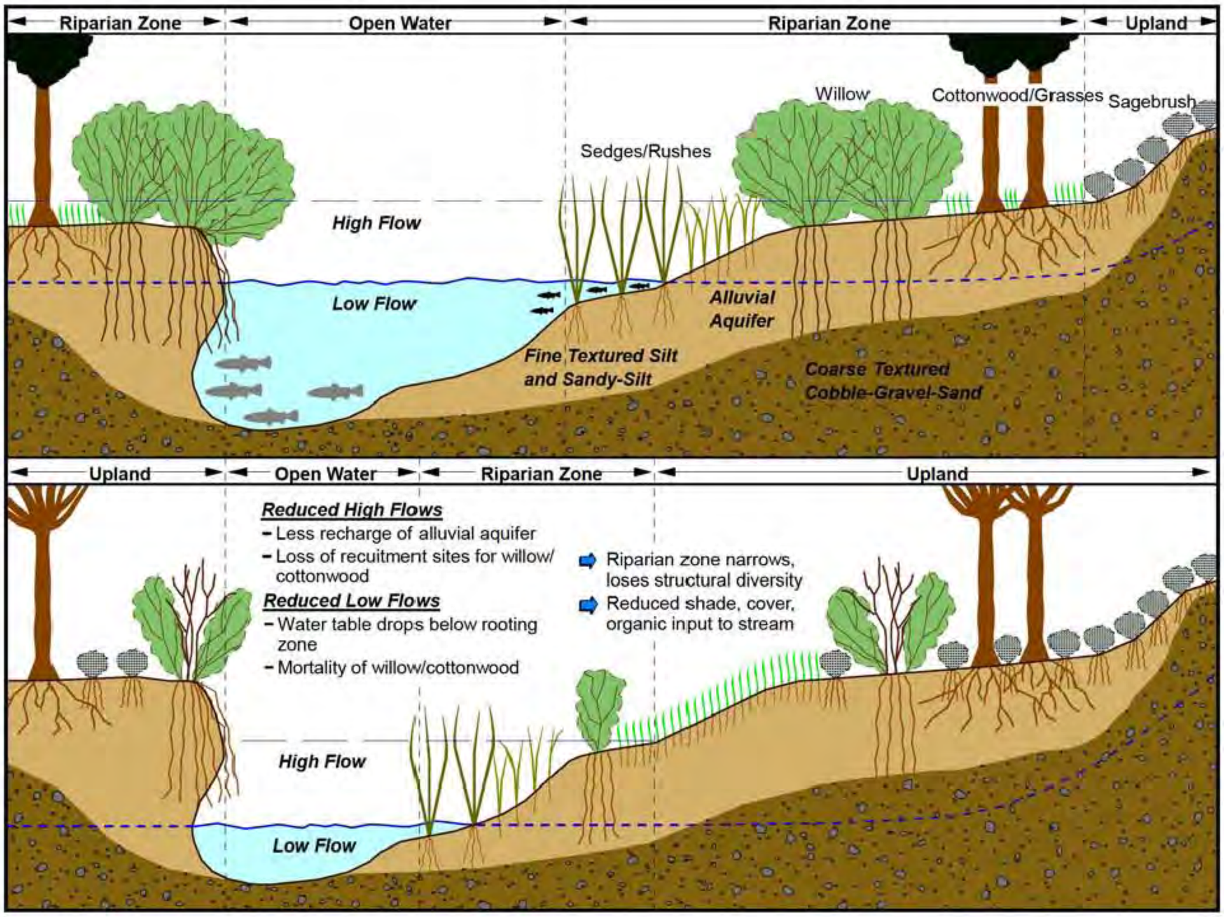


Figure IV-4. Diagram representing general effects of flow reduction on riparian habitats and its functionality. Riparian habitat is fish habitat as Naiman and Latterell's (2005) third principle notes.

62. Was the third principle (riparian zone is fish habitat) incorporated into developing the Physical Habitat Claims?

Yes. The work to develop the Physical Habitat Claims in combination with the Riparian Habitat Claims focused on maintaining the linkages between and functionality of both the needs of the aquatic system contained within the confines of the two stream banks and the adjoining riparian zone. Both of these are necessary ingredients in sustaining overall healthy and productive fish habitats. Without flows sufficient to maintain a healthy and productive riparian zone, the linkages between the physical habitat within and riparian habitats adjoining the stream would be de-coupled, creating a decrease in the health and productivity of habitats proximal to and for some distance downstream from the affected area.

63. Please describe Naiman and Latterell's fourth principle which you stated is an underpinning to healthy and productive fish habitat.

The fourth principle for a healthy, productive habitat is that fishless headwater streams are inseparable from fish-bearing rivers downstream. This principle relates directly to the second principle (linkage) noted above, in that conditions existing at any point within a stream reflect the physical, chemical, and biological inputs emanating from upstream sources. Indeed, there is often an identifiable location within a stream that marks the point upstream of where fish do not reside. While there may be physical barriers that block upstream movements of fish that prevent them from reaching and inhabiting upper segments of a stream, the waters emanating from these upper "fishless" streams represent important pathways for transporting nutrients, sediments, and food (invertebrates) to downstream reaches that harbor fish. Naiman and Latterell (2005) noted that the inputs received from upper stream segments contribute materials to downstream food webs and help shape the structural characteristics of fish habitats in lower reaches. Thus, even though sections of stream within these upper watersheds are fishless, it is important that they are protected and that sufficient flows be allowed to reach the downstream segments of stream that contain fish.

64. Was the fourth principle (fishless headwater streams are inseparable from downstream fish-bearing rivers) incorporated into developing your Physical Habitat Claims.

Yes. There are fishless headwater streams within the Wood River subbasin that exist above the claim reaches. Although not explicitly claiming waters in these streams, the instream flow claims for the Wood River subbasin implicitly afford some protection to these upstream systems and their physical, chemical, and biological inputs. This is because the headwater streams are contributory to the flows specified in a given downstream reach and therefore contribute to the formation of healthy and productive fish habitats. Indeed, the Physical Habitat and Riparian Habitat flow claims that are made downstream rely in part on flows from these smaller, fishless, tributaries. Thus, the provision of flow claims within the reaches of stream that contain fish, will by extension afford some protection to flows in the fishless systems.

65. Please describe Naiman and Latterell's fifth principle which you stated is an underpinning to healthy and productive fish habitat.

The fifth principle for a healthy, productive habitat is that fish may utilize different habitats, in different locations, and at different times in their life-cycle. Some fish species migrate from and to lake systems (adfluvial), from and to large river to small river systems (fluvial), from one section of the stream to another section within a relatively small distance (resident) and between ocean and freshwater habitats (anadromous). Such migration periods are typically genetically programmed to occur within a set time period that has been established by evolution to provide the greatest advantage for the success of that particular lifestage.

66. Was the fifth principle (fish may utilize different habitats, in different locations at different times) incorporated into developing the Physical Habitat Claims?

Yes. In developing the Physical Habitat Claims, consideration was expressly given to flows necessary to provide for specific life history needs including spawning, egg incubation, adult and juvenile rearing, and fry habitats. In addition, although a specific claim for a given month may have been directed toward a certain species and lifestage, the claim was reviewed in the context of its influence on other target/keystone species and lifestages that may co-exist at the same time. This was done as a check to make sure that the provision of flows intended to promote healthy and productive habitats for one species and lifestage would not severely impact the habitats of another.

67. Please describe the remaining sixth, seventh, and eighth Naiman and Latterell principles which you stated are underpinnings to healthy and productive fish habitat.

The remaining principles for a healthy, productive habitat are: habitats change over hours and over centuries (sixth principle); fish production is dynamic, due to bio-complexity in species in habitats and between the two (seventh principle); and management and conservation strategies must evolve rapidly in response to present conditions, but especially the anticipated future (eighth principle).

I group these last three components together since they all contain a "time" element. The sixth principle connotes the realization that habitats are not static but are continually changing in response to global, regional and local influences (sometimes called "forcing factors") such as those imposed by climate and weather-related events. The seventh principle links biology to these same forcing factors which can cause intra- and inter-annual changes in fish production. The final, eighth, principle stresses that management strategies should be adaptive and flexible in responding to future conditions.

68. Were the sixth, seventh, and eighth principles, (habitats are not static but continually changing biology; fish production is dynamic; and management strategies should be adaptive and flexible) incorporated into developing the Physical Habitat Claims?

Yes. The sixth, seventh, and eighth principles reflect a time component and the realization that habitats and associated aquatic biota that exist at any given time are not static and will change in response to a variety of forcing factors. The sixth and seventh of these time-related principles (continuously changing habitat and dynamic fish production) were considered in both the Physical Habitat and Riparian Habitat Claims developed for the streams of the Wood River subbasin and relate to the hydrologic statistic applied to each. That is, as further described in Section VII, the Physical Habitat Claims are founded around the hydrologic statistic of the median, or 50 percent exceedance flow. The median flow is the flow amount equivalent to the value that would be equaled 50 percent of the time. In years of higher flow, the claimed flow may be exceeded, whereas in years of low precipitation and runoff the flows occurring may not attain the median level. In that sense, although specific flow values have been claimed for each month, there will be inter-annual variability in the amount of flows that actually occur. Likewise and as more completely described in Dr. Chapin Direct Testimony at questions 31 and 50, the Riparian Habitat Claims are hydrologically limited and thus subject to inter-annual variability.

The final time-related principle, adaptive management, was considered; however, adaptive management is a form of resource management in which actions are implemented as experiments from which to learn and appropriately modify future actions. Such flexibility is not inherently possible under a water rights adjudication such as this, which specifically quantifies water rights with finality and does not operate within an ongoing adaptive management framework.

69. Dr. Reiser, please summarize how the Naiman and Latterell principles were brought together in your analysis.

These principles served as guide posts for developing the Physical Habitat Claims. They served to highlight the ecological linkages that must be met by the claims; linkages that are based on important life history requirements of the target fish species that are influenced by streamflow.

70. Please describe how streamflow specifically affects or meets a fish's life history requirements and biological needs.

As I described above with respect to the stream flows associated with the Physical Habitat Claims, I distinguish two different stream functions directly relevant to fish and fish physical habitat. First, streamflow provides physical space within which fish and other aquatic organisms can live. Second, streamflow provides the necessary hydraulic energy and forces to create and maintain physical structures and ecological function in and along the channel including pools, riffles, spawning areas (through the deposition of new gravels and flushing of fine sediments within existing gravels), off-channel habitats, and riparian communities. Both functions are necessary to promote healthy and productive habitat for fish.

Importantly however, as noted in Naiman and Latterell's fifth principle, habitat requirements can differ by fish species and their life history stage. For the target fish species present in the Wood River subbasin, the key lifestages include spawning, incubation, fry, juvenile, and adult.

71. Are the fish lifestages connected to each other?

Yes. Collectively, lifestages represent the major steps that a fish progresses through as part of its life cycle. Just as the human life cycle can be characterized as a series of stages that include conception, birth, youth, adolescence, adulthood, etc., the life cycle of fish can be captured in a series of lifestages that represent important biological activities. For convenience, I have included Figures IV-5 to IV-10 that display the life cycle diagrams and general periodicities for each of the target species that are currently or were historically found in the Wood River subbasin, including redband trout, bull trout (historically present), Chinook salmon (planned for reintroduction), Lost River sucker, shortnose sucker, and Klamath largescale sucker.

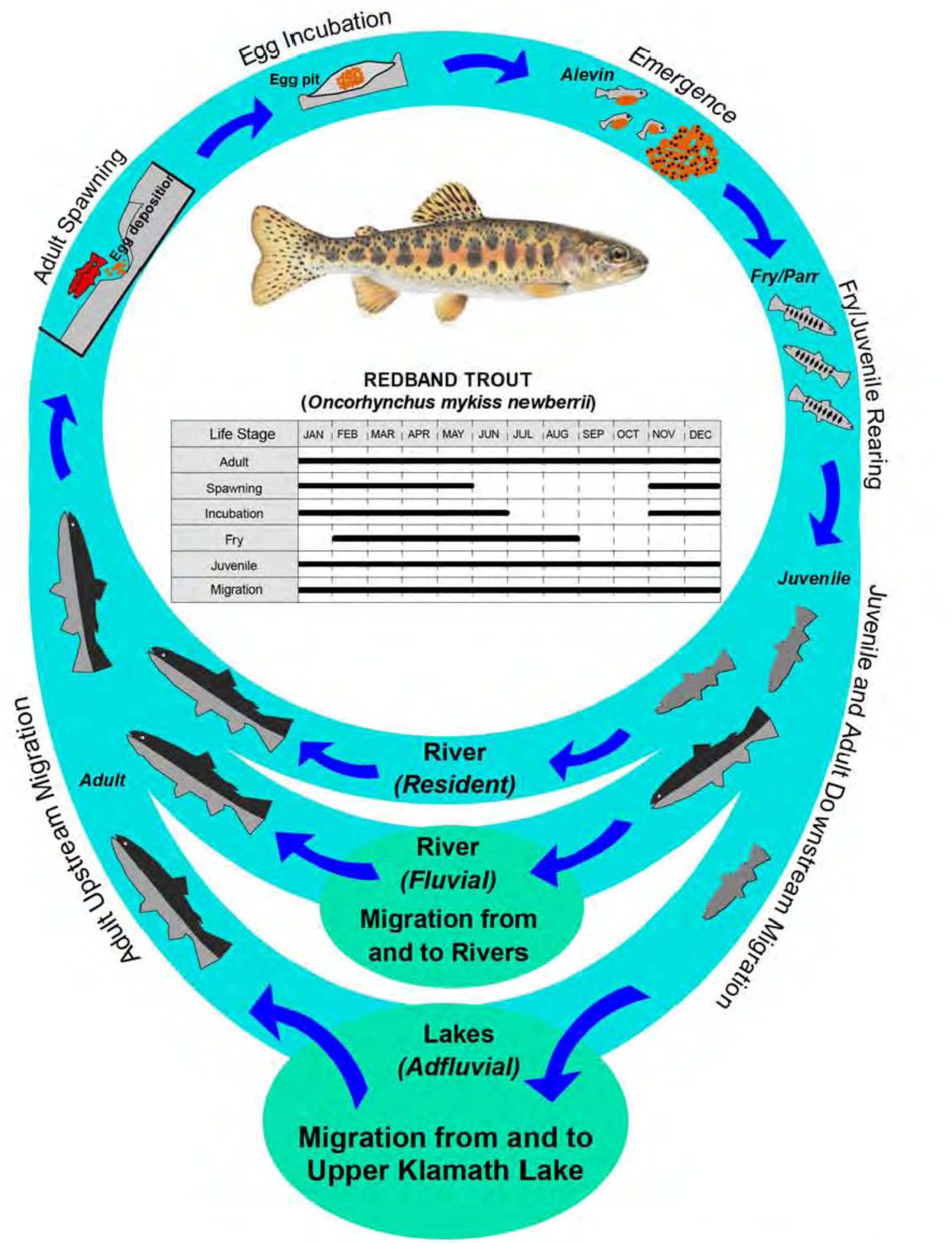


Figure IV-5. Life cycle diagram of redband trout depicting three life history strategies (adfluvial, fluvial, and resident) that occur in the Wood River subbasin. A general periodicity chart is presented in the center of the diagram that shows the timing of lifestage functions throughout the year.

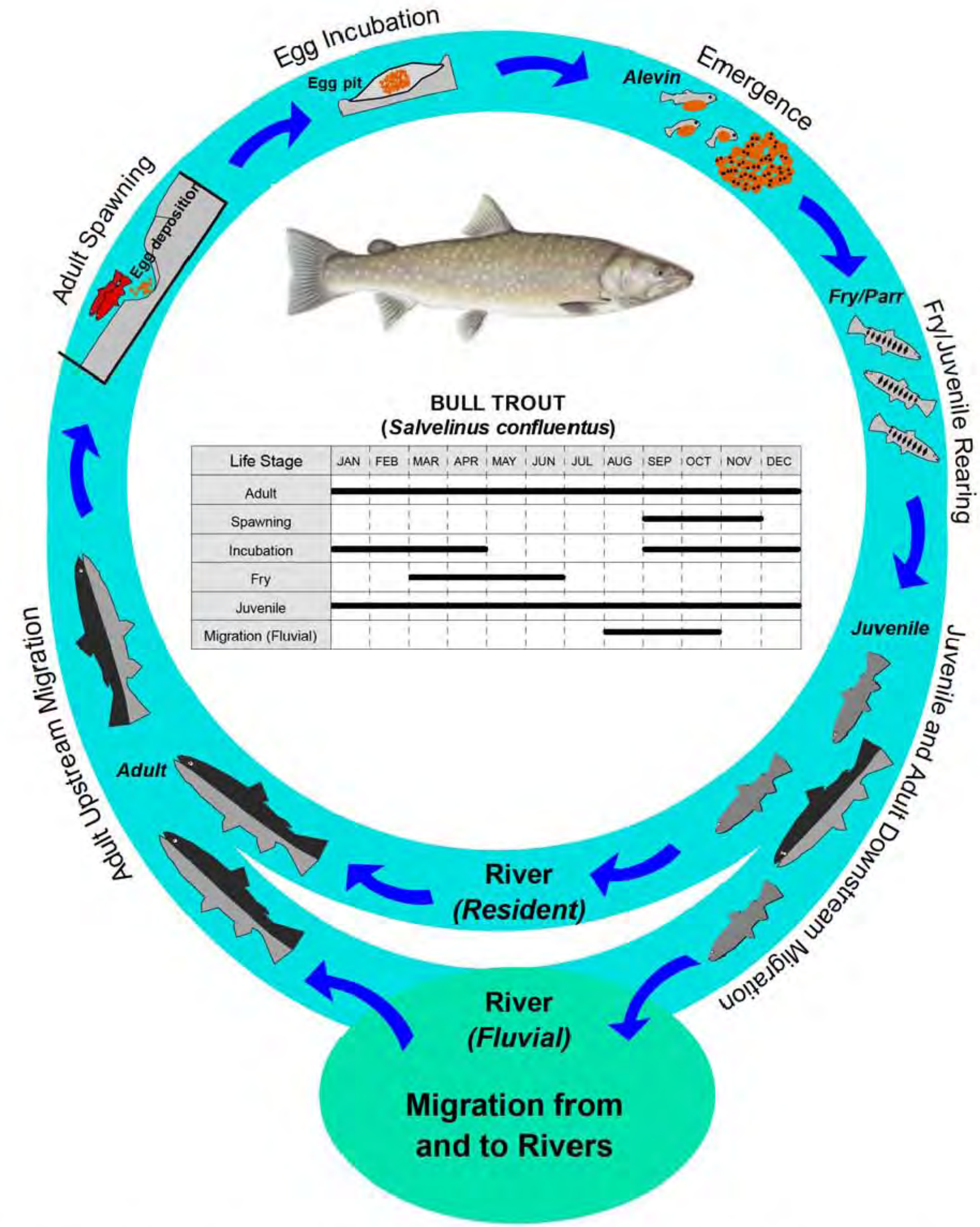


Figure IV-6. Life cycle diagram of bull trout in the Wood River subbasin. All current populations of bull trout in the basin exhibit a resident-type life history strategy. Historically, bull trout extended further downstream in the subbasin and likely exhibited a fluvial life history strategy. A general periodicity chart is presented in the center of the diagram that shows the timing of lifestage functions throughout the year.

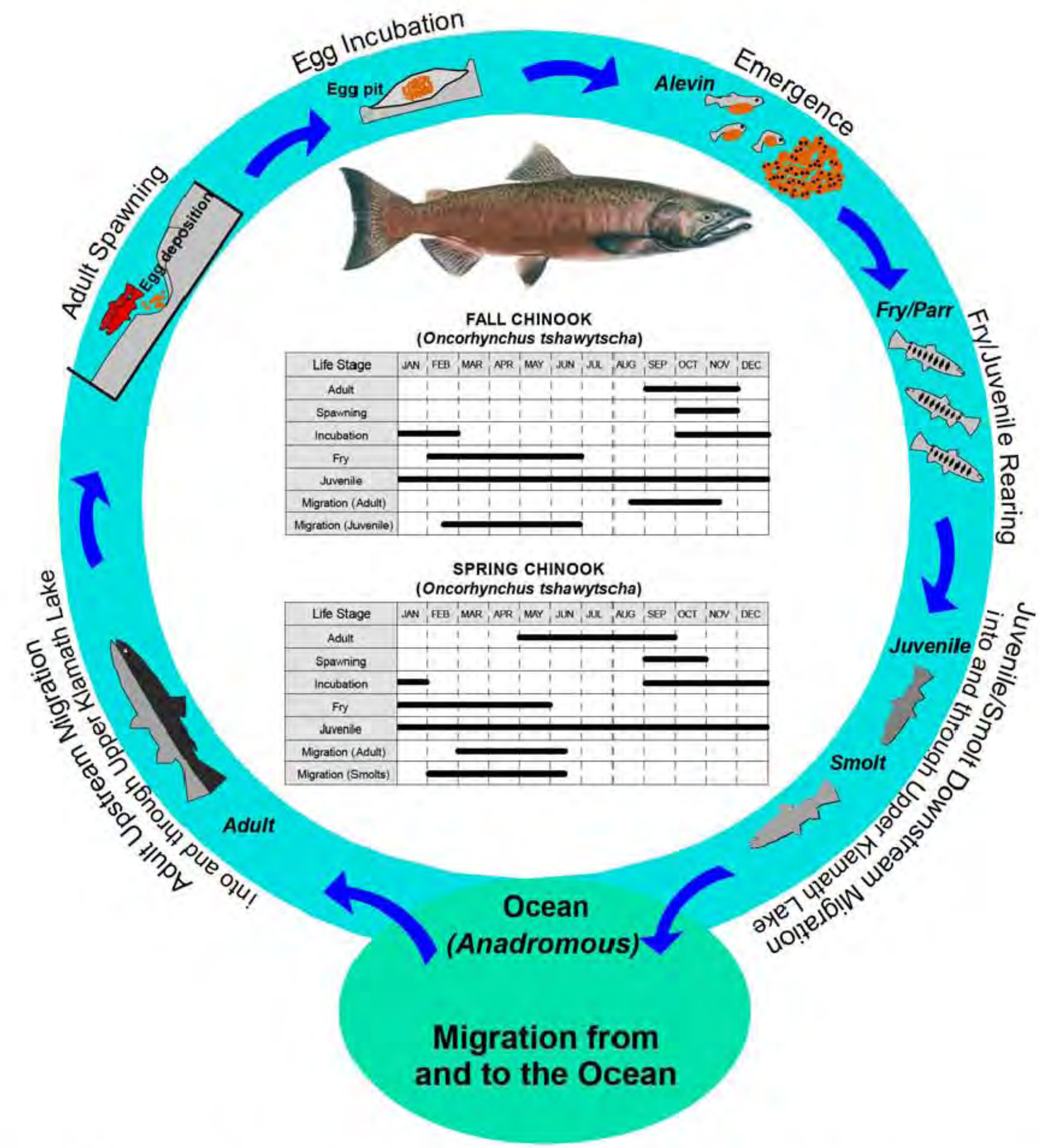


Figure IV-7. Life cycle diagram of Chinook salmon for part of the Wood River subbasin. Chinook salmon were historically present and are proposed for reintroduction into the Upper Klamath Basin. Two races of Chinook salmon will likely be present, spring Chinook and fall Chinook. Adult spring Chinook enter freshwater in the spring and migrate upstream into the upper watershed where they hold until ready to spawn. Fall Chinook enter in the fall and migrate upstream to areas wherein they commence spawning shortly after arrival. As juveniles, spring Chinook typically remain and rear in freshwater from 1 to 2 years before migrating downstream to the ocean. As juveniles, fall Chinook spend a relatively short time in freshwater and generally commence moving downstream shortly after emerging from the gravels. All Chinook salmon adults die after spawning. Separate periodicity charts are presented in the center of the diagram that show the timing of lifestage functions throughout the year.

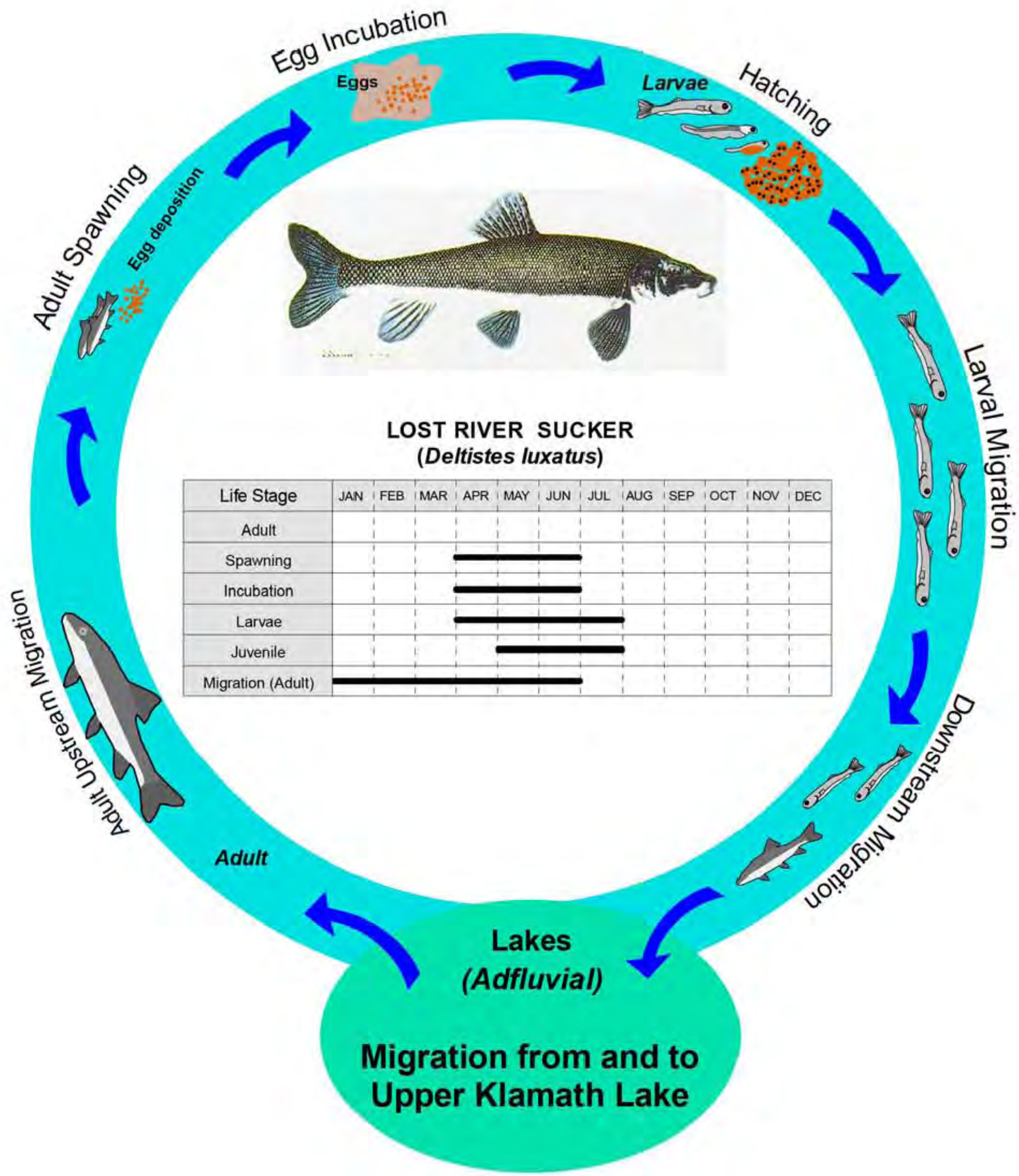


Figure IV-8. Life cycle diagram of Lost River sucker in the Wood River subbasin. Lost River sucker exhibit an adfluvial life history strategy with adults residing in Upper Klamath Lake until they are ready to spawn, at which time they migrate upstream into the Wood River to find spawning areas; afterwards, they return to the lake. A general periodicity chart is presented in the center of the diagram that shows the timing of lifestage functions throughout the year.

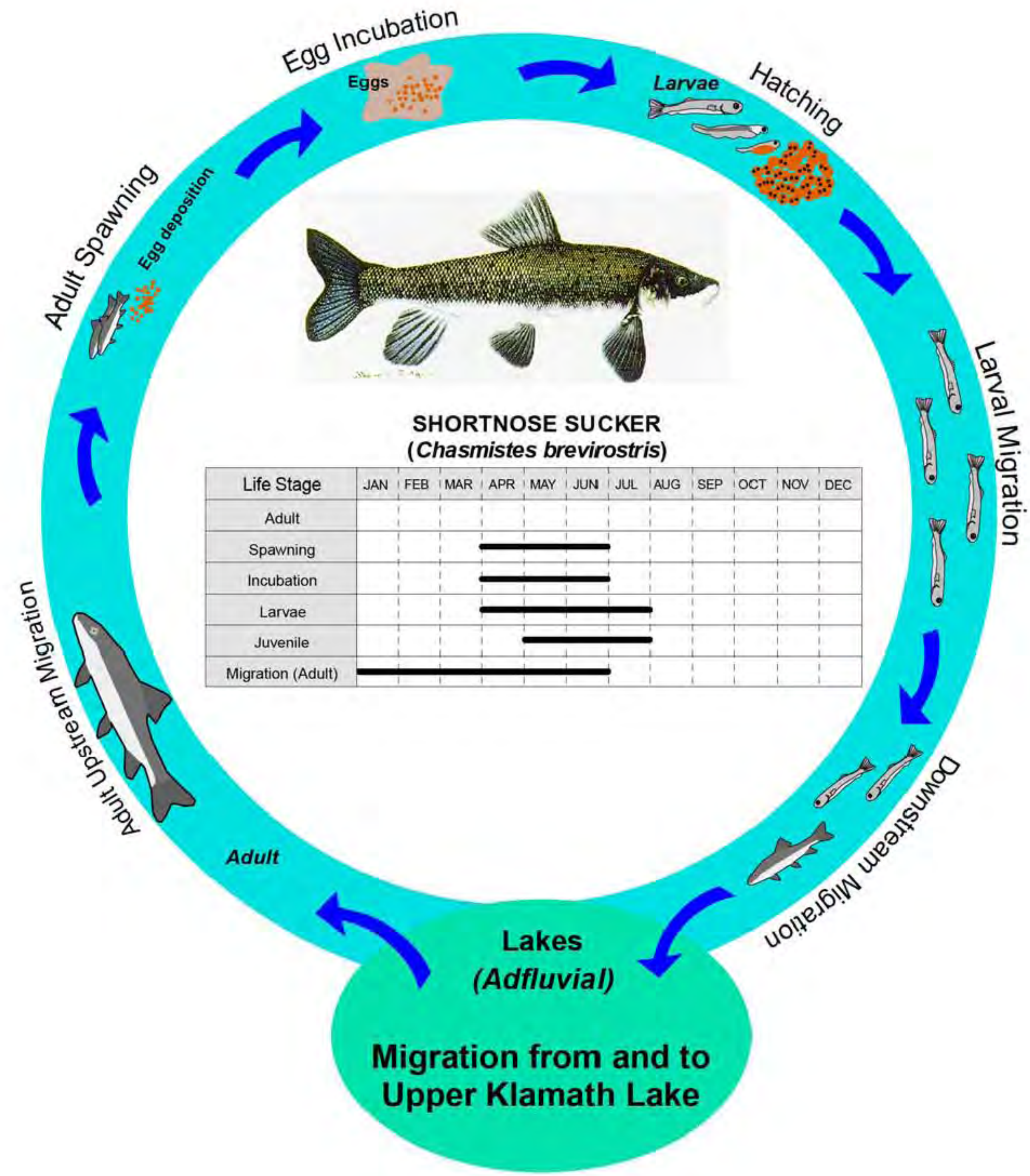


Figure IV-9. Life cycle diagram of shortnose sucker in the Wood River subbasin. Shortnose sucker exhibit an adfluvial life history strategy with adults residing in Upper Klamath Lake until they are ready to spawn, at which time they migrate upstream into the Wood River to find spawning areas. A general periodicity chart is presented in the center of the diagram that shows the timing of lifestage functions throughout the year.

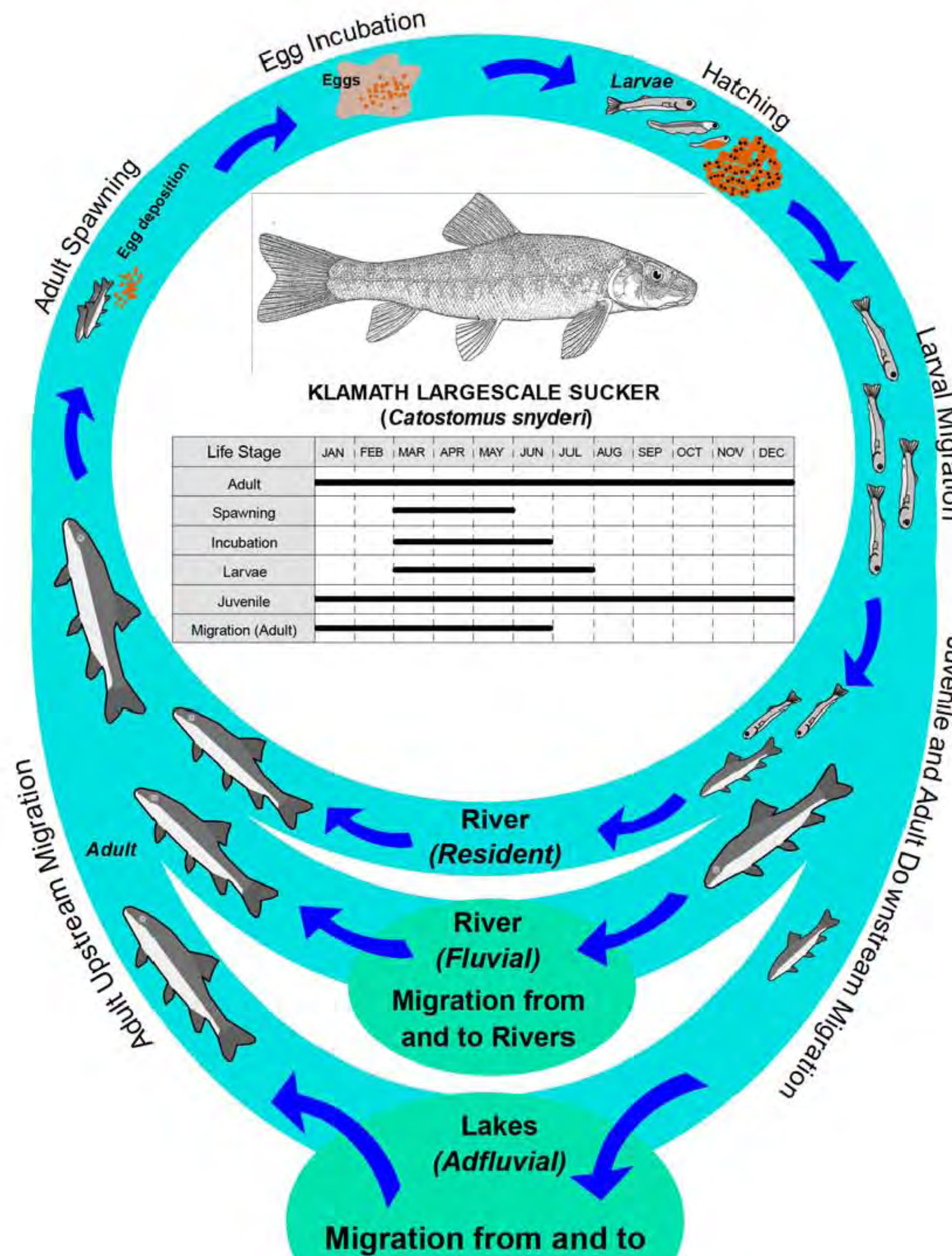


Figure IV-10. Life cycle diagram of Klamath largescale sucker in the Wood River subbasin. Klamath largescale suckers exhibit three life history strategies (adfluvial, fluvial, and resident) in the Wood River subbasin. A general periodicity chart is presented in the center of the diagram that shows the timing of lifestage functions throughout the year.

72. Do all of the target fish species have the same life cycle?

In a general sense, yes. All include some type of spawning stage, followed by egg incubation and hatching of fry or larvae; a juvenile stage marked by increased growth; and an adult stage in which the fish has reached sexual maturity. Afterwards, the life cycle of the species repeats; however, differences do exist between the target fish species in the timing of these lifestages, as well as with the locations where they occur.

73. Please explain what you mean by differences in timing.

With respect to timing, differences occur among the target fish species in terms of whether and when adults migrate (upstream and downstream); when they spawn; whether and when post-spawning adults migrate downstream; when eggs hatch; when fry emerge; whether and when fry/larvae migrate (downstream); and whether and when juvenile fish migrate (downstream). Collectively, these timing differences are what biologists consider as elements of the periodicity of the lifestage; i.e., when a given lifestage occurs during the year.

74. Please explain what you mean by the differences in locations.

Differences in locations reflect where in a given stream certain lifestage functions occur, such as spawning and incubation, juvenile rearing, and adult holding and rearing. For example, certain locations within a stream may be used for spawning by some target species, and other locations used by different species. Likewise, differences exist as to where adult members of each target species typically reside: some spend most of their time in Upper Klamath Lake (adfluvial fish), some in the larger mainstem portion of a river (fluvial fish), others in tributaries (resident fish), and some species have life history strategies that utilize two and in some cases all three of these areas.

75. Are those the only differences between the target fish species?

The life cycle differences I have described are some of the major differences between species; however, other significant differences exist between one of the target fish species, Chinook salmon, and the other species. First, Chinook salmon are anadromous and spend the majority of their time in the ocean where they feed and grow to maturity. They then enter the freshwater river system of their origin and migrate upstream *via* a homing instinct (olfaction that allows the fish to recognize specific odors and water quality characteristics) to locate a specific tributary or segment of stream to spawn. Chinook are strong swimmers and in some drainages migrate over 1000 miles to reach their natal spawning areas. Second, adult Chinook salmon die after they spawn, while adult members of the other target species do not necessarily die after spawning. The adults of other target species may spawn again for several more years.

76. Please describe the flow and habitat requirements associated with spawning, egg incubation, and fry emergence of young fish.

The habitat conditions that meet the reproductive or spawning requirements of the target fish species in the streams of the Wood River subbasin are in my opinion the most important habitat conditions relative to sustaining a healthy and productive habitat. The conditions that exist during the period in which eggs are deposited in the gravel nests (called "redds"), embryos incubate and hatch, and young fish, (called "fry") subsequently emerge are primary determinants of the species year-class-strength (the ultimate numbers of fish that may be recruited into the fish population and return as adults) (Quinn 2005). Year-class-strength can vary widely interannually due to combinations of physical and hydraulic characteristics of the stream and the variation in climatic conditions.

The key components of spawning habitat include sufficient streamflow, proper substrate (gravels), temperature, and sufficient cover. The influence of streamflow on redds and egg incubation occurs in both a quantitative and qualitative manner. Quantitatively, streamflow regulates the amount of spawning habitat/area within a stream by determining the extent to which spawning gravels are submerged with the proper combinations of water depth and water velocity that have been shown to be used by adult fish (Bjornn and Reiser 1991). Fish are known to select specific areas in a stream that contain certain sizes of gravels, and certain combinations of water depth and velocity. The amount of flow in a stream largely determines the amount of suitable spawning habitat that is present. The topmost panel of Figure IV-11 illustrates conditions where water depths and velocities are suitable for spawning. In the case of salmonids such as redband trout, the female creates a depression in the streambed by repeated flexing movements (wriggling) of her body. Once the depression is of sufficient size, the female and male enter the depression where spawning occurs (i.e., simultaneous release of eggs and sperm). After spawning, the female moves just upstream and via additional flexions of her body, covers the fertilized eggs with gravel, which is what is illustrated in the figure. These fertilized eggs (embryos) remain in the gravels for a prolonged period of time that extends through hatching (at which time the newly hatched fish are called alevins; alevins receive all of their nutrients from an attached yolk sac), and up until absorption of the yolk sac at which time the fry emerge from the gravels. This entire period can extend from 3 to 6 months depending on water temperatures. Thus, sufficient streamflow is important throughout the incubation period (from egg deposition through fry emergence) to provide and maintain suitable conditions within the gravels (i.e., water temperature and oxygen). As illustrated in the lower panel of Figure IV-11, severe reductions in flow may result in the dewatering of redds and exposing the eggs/embryos to air, desiccation, and intolerable temperatures. The conditions exemplified in the lower two panels of Figure IV-11 do not portray healthy and productive habitat.

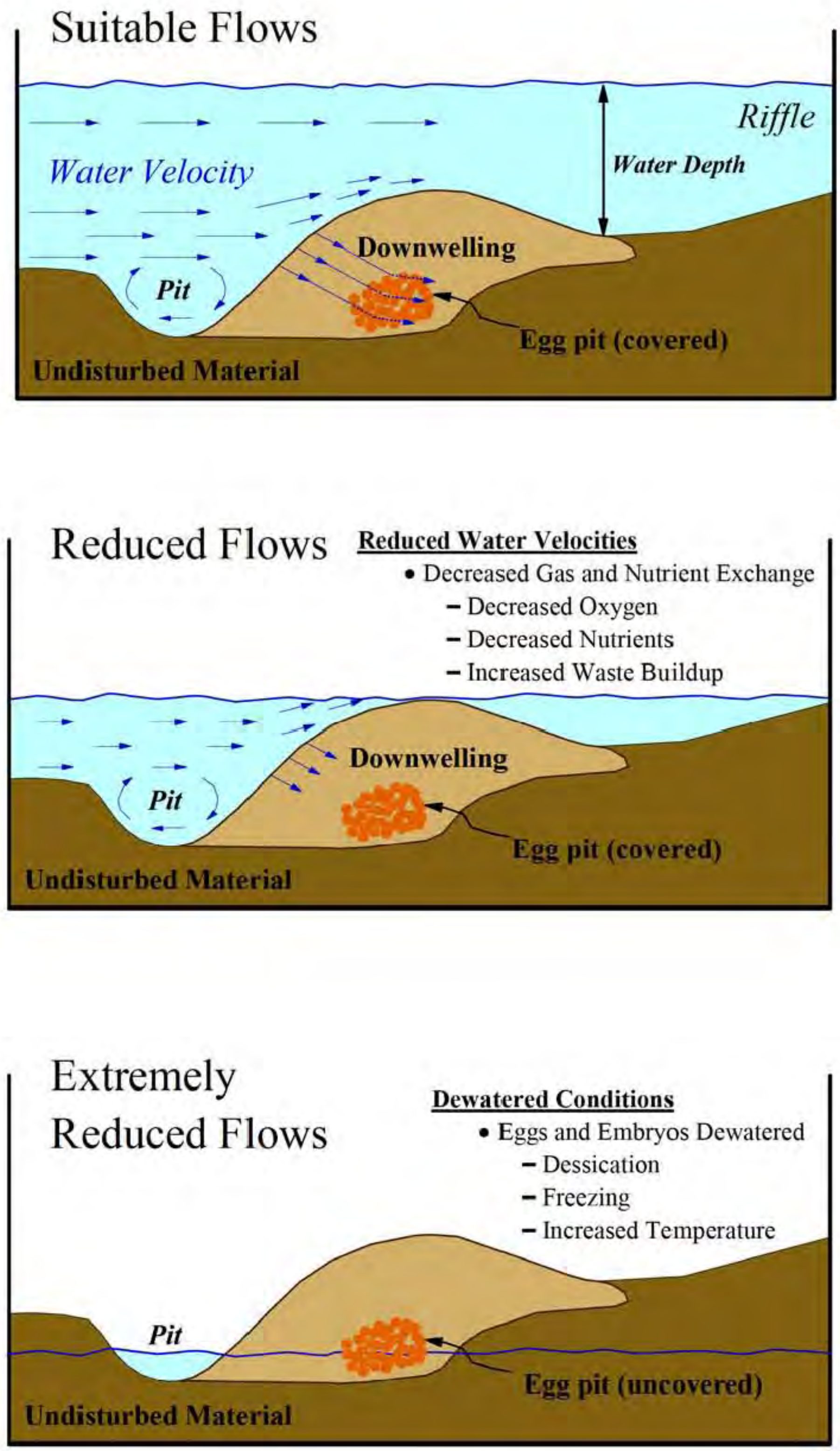


Figure IV-11. Conceptual diagram of salmonid redds illustrating generalized effects of streamflow reductions on the intragravel environment.

Qualitatively, streamflow plays an important role in providing and maintaining the quality of the spawning gravels. These flows typically serve, among other things to mobilize and transport fine sediments from spawning gravels which is important for increasing gravel permeability (rate of flow transport through the gravels) and facilitating the interchange of surface and intragravel flows as illustrated in the top and middle panels of Figure IV-11. This interchange is critical for the successful incubation of deposited eggs since the flows result in the transport of oxygen to and removal of metabolic wastes from the embryos (Reiser and White 1983; Wickett 1954; and Chapman et al. 1982). In general, as the amount of surface flow decreases there will be less down-welling of currents into the redds, which can reduce the supply of oxygenated waters to the developing eggs, and may increase mortality.

77. What role, if any, does cover have in spawning and incubation?

Cover (i.e., deep pools, surface turbulence, large wood, undercut banks and overhanging vegetation (Bjornn and Reiser 1991)) is regularly relied upon by adult fish both during their upstream migrations and during spawning. Such cover can protect the spawning fish from disturbance, predation, and high water velocities. Instream cover such as large wood can also protect the redds from high water velocities and scouring and removal of eggs from the gravel. All of these cover components are influenced by streamflow and all are likewise important ingredients of healthy and productive habitat.

78. Please describe the relationship of streamflow to stream temperature and spawning and egg incubation habitat.

The timing of spawning of salmonid and sucker species is closely linked to water temperatures (Bjornn and Reiser 1991). In the streams within the Wood River subbasin, water temperatures are likely primary determinants of when fish spawn, how long the eggs incubate (development is directly related to water temperature (Leitritz and Lewis 1980)), and when fry emerge and become free-swimming. Factors that may alter such temperatures and, therefore, affect spawning and incubation include flow depletions/diversions, and loss of riparian vegetation. Water temperature is thus an integral component of healthy and productive habitat.

79. Please describe the flow requirements associated with fry and juvenile habitat.

Subsequent to emergence from the gravels, the fry must find cover and begin to feed and grow. Because of their relatively small size (<30 mm), fry generally seek habitat that has abundant cover (to provide shelter from predators) and low velocities since they are not strong swimmers. These habitats are typically found along stream margins and in off-channel and backwater areas of streams. As fry grow and become juveniles, their swimming abilities increase and they can assume different locations in the stream to feed and continue growing. These habitats can be quite diverse and perhaps more complex than any other life history stage. As in spawning, streamflow is the primary determinant of a number of specific factors that contribute to defining suitable rearing habitat. These factors include but are not limited to water depth, water velocity, pool volume, water temperature, dissolved oxygen, substrate quality, and in many instances, physical structure and habitat such as large woody debris. Similar to those for spawning, these factors can be divided into those imparting a quantitative effect and those that are qualitative. The amount of flow in a river has a direct influence on the distribution and quantity of water depths and associated velocities that are most often utilized by fry and juvenile salmonids and sucker species. Chapman (1966) considered velocity to be perhaps the more important of the two factors, noting that without suitable velocities, no fish will be present. Relative to suckers, velocities are important in terms of transporting the larval suckers from spawning areas downstream to the lake where food and space are abundant. Studies have shown that fry of salmon and trout typically utilize velocities less than 0.3 feet/second (Chapman and Bjornn 1969; Everest and Chapman 1972; Griffith 1972). As fish grow, they become stronger and are often associated with higher water velocities (Smith and Li 1983). Shifts in velocity usage by fish have been observed seasonally, presumably in response to water temperature changes. The shifts are generally from higher velocities in the summer feeding periods to lower velocities during the winter holding periods (Chisholm et al. 1987; Tschaplinski and Hartman 1983).

Water depths used by salmonid fry and juveniles can be quite variable depending on associated factors, e.g., substrates, cover, food, velocity, predator density. Newly hatched fry often utilize the extreme edge habitats of a stream where velocities are low and there are few predators. As fish grow they are capable of using deeper waters with limits of use generally related to some other interrelated parameter such as water velocity. Bjornn and Reiser (1991) noted that some salmonids are found in higher densities in pools than other habitat types as a result of space availability. Again, there are probably other factors acting to regulate such densities; for example, the presence of large woody debris or overhanging vegetation can have a direct, positive benefit on increasing the carrying capacity of a given pool (see Figure IV-2).

Streamflow can and does regulate the carrying capacity of rearing habitats. This is illustrated conceptually in Figure IV-1, which portrays how the numbers of fish that are able to exist within a given pool changes in response to reductions in flow. Such reductions can occur naturally, (e.g., via the seasonal progression of flows from high spring runoff conditions to summer low flow conditions), and/or from human regulation, (e.g., the diversion of flows for irrigation). Figure IV-1 can be used to illustrate both. In this case, the upper panel might represent conditions occurring naturally under high flows, and the middle panel, natural conditions during summer/fall low flows. Under the relatively high flow conditions, the rearing areas encompassing pool:run:riffle habitats will afford living space for a certain density of fish as set by the other limits of food availability, space, cover, and water quality characteristics.

80. Please describe the relationship of cover to juvenile and fry habitat and streamflow.

Cover in the form of water depth, turbulence, boulders, large woody debris, undercut banks and overhanging vegetation is an absolutely essential component during the fry and juvenile lifestages. These features provide shelter from fast velocities, refuge to escape from predators, and areas from which to base feeding opportunities. Streams without cover or with limited cover will inherently have lower carrying capacities simply because there will be increased predation and therefore increased mortality of both fry and juvenile lifestages. This is illustrated conceptually in Figure IV-2 which depicts a given segment of stream under the same flow condition but having varying amounts of cover. In this figure, the upper panel contains the greatest amount of cover and has the highest carrying capacity. The two lower panels possess progressively lower amounts of cover and hence have reduced carrying capacities.

Importantly, the amount of flow in a stream can influence the usability of the cover features. That is, as flows increase or decrease, water depths and velocities that are associated with the cover feature will increase beyond or decrease below points where fish will use it. Severe reductions in flow may result in a narrowing and pulling away of the wetted channel from the stream banks, essentially decoupling the stream from cover features provided by vegetation of the riparian zone. In addition to influencing the usability of cover, streamflow of sufficient magnitude actually creates and maintains cover features in a stream, including connectivity to the riparian zone, which is the focus of the Riparian Habitat Claims.

81. Please describe the relationship of streamflow to stream temperature and juvenile and fry habitat.

Water temperature directly influences the survival and growth of fry and juvenile salmonids as well as other fish species. Salmonids and other species have evolved around and prefer certain ranges of temperatures that are conducive to their growth and promote general health. These temperature ranges are directly influenced by the natural flow regime that has developed within each stream system in response to regional and local topographic and orthographic features. Prolonged changes in temperature beyond the ranges conducive to the fish's normal growth have been shown to increase stress and render the fish more susceptible to disease outbreaks (Guillen 2003a). The water temperatures in streams within the Upper Klamath Basin are influenced by patterns of flow that occur in the run-off dominated streams as well as spring-dominated streams. As discussed more in Section V of my testimony, the Upper Klamath Basin experiences the benefit of numerous cool water springs. These spring-dominated streams can have a dramatic effect on temperatures in other streams that receive flows from these systems.

82. Please describe the flow relationships associated with adult fish habitat.

The juvenile lifestage continues until the fish matures and gonads become functional. At this time, the fish is considered an adult and can participate in the spawning process, which for some species (e.g., resident and adfluvial salmonids and suckers) can occur over many years.[2] For the adult lifestages, streamflow is an important determinant of a number of specific factors that contribute to defining suitable adult holding areas (areas adults remain in before spawning)

2 Salmon and steelhead juveniles first migrate to the ocean as smolts, where they feed and grow until they mature to be adults and then return to fresh water to spawn.

in a riverine habitat. Factors affecting the adult lifestage that are benefited by streamflow include but are not limited to water depth, water velocity, pool volume, water temperature, and dissolved oxygen. In general, increases in flow tend to increase the quantity and quality of adult habitat by providing more space, improving water quality conditions, increasing the number of feeding stations, and enhancing the utility of instream cover such as large wood and boulders.

83. Please describe the flow relationships associated with upstream migration of adults for spawning.

In the case of Chinook salmon and steelhead trout, as well as populations of fluvial and adfluvial redband trout in the Wood River subbasin, strong homing and migrating instincts can result in adults seeking and finding the same streams and in many cases the same spawning areas within those streams in which they were produced. This homing capability has been shown to be linked to olfactory imprinting wherein juvenile fish essentially remember the specific bouquet of odors they encounter as they migrate downstream to the ocean. As noted by Bjornn and Reiser (1991), adult salmonids (as well as sucker species) returning to streams to spawn must do so at the proper time and with sufficient strength and energy to complete their life cycle. Although salmonid stocks have evolved such that successful migrations can usually occur under a variety of conditions (owing to differences in migration timing), man-induced and in some cases natural events can result in sufficient delays in migration to impair at least a portion of the spawning population and hence reduce egg and fry production.

Successful adult upstream migration is dependent on a variety of factors, all of which are related to streamflow. These factors include water depth, water velocity, water temperature, dissolved oxygen, turbidity, and no physical barriers (Bjornn and Reiser 1991).

84. You just stated that adult upstream migration is dependant on a variety of factors, including depth and velocity. Please explain the relationships of water depth and water velocity to adult fish migration activities.

Without sufficient streamflow in a stream or river, adult fish can not successfully migrate upstream to spawning areas. The quantity of such flows necessary for passage has been evaluated by a number of investigators who have assessed passage requirements on the basis of the percentage of the average annual flow (Baxter 1961) and on specific water depths and water velocities adult fish are capable of migrating through (Thompson 1972). For trout and salmon, adult migration is defined in terms of minimum water depths that range from 0.4 to 0.8 feet and maximum water velocities that range from 4.0 to 8.0 feet/second (Thompson 1972). These represent minimum depth and maximum velocity criteria and must be evaluated in the context of applying such to stream reaches that pose as potential migration barriers, such as wide, shallow riffles.

85. You stated that adult upstream migration is also dependant on water temperature. Please explain the relationship of water temperature to adult fish migration activities.

Because salmon and trout are cold blooded (poikilotherms), their metabolism and life history functions are closely linked to water temperatures. In the case of upstream migrations, water temperatures that are too warm or too cold have been reported to influence migration timing and may result in delays (Hallock et al. 1970; Bjornn and Reiser 1991).

Factors that can lead to altered thermal regimes in streams in the Wood River subbasin include but are not limited to removal of riparian vegetation and forest canopy, irrigation withdrawals, and irrigation return flows. Such effects vary seasonally.

86. A third factor that you stated adult upstream migration is dependent upon is dissolved oxygen. Please explain the relationship of dissolved oxygen in water to adult fish migration activities.

Adult fish that are migrating are dependent on acceptable levels of dissolved oxygen (DO). In general, for salmonids, concentrations should be close to 8 mg/L, or at or near saturation levels in streams and rivers (Davis 1975; Bjornn and Reiser 1991). Suckers likewise require suitable DOs but generally can withstand lower concentrations than salmonids. The Washington Department of Ecology (WDOE 2002) reviewed various data and concluded that swimming fitness of salmonids is maximized when the daily minimum dissolved oxygen levels are above 8 - 9 mg/L. The amount of DO in streams is a product of atmospheric exchange with the water surface as well as the temperature of the water. Thus, concentrations of DO are influenced by surface agitation and resulting re-aeration that typically occurs in riffles and cascades. The amount of flow in a stream can affect the degree of re-aeration associated in these areas; increases in DO generally occur with higher flows that increase surface agitation, while decreases in DO occur with lower flows and surface agitation.

87. Finally, you stated that successful adult upstream passage requires there be no impassable, physical barriers. Please explain the relationship of physical barriers in water to adult fish migration activities and streamflow.

Physical barriers such as waterfalls, debris jams, and artificial structures (e.g., dams, irrigation flow deflectors) can delay or prevent upstream migration of adults. Salmon and trout have certain swimming and jumping capabilities that vary by species (Bell 1986; Powers and Orsborn 1985, Reiser and Peacock 1985). Darting speeds (maximum speeds attainable over a short period of seconds) reportedly range from about 6 feet/second for certain trout species to over 26 feet/second for steelhead trout (Bell 1986). Streamflow can directly influence the passage conditions at potential barriers. For example, under conditions of low flow, a particular set of falls or rapids may create conditions that exceed the combined jumping and swimming capabilities of salmon and trout, and hence, serves as a barrier to upstream migration. Under higher flow conditions, these same areas may become passable.

88. Why would the boundaries of the original Klamath Reservation not serve as barriers that would prevent further upstream migrations of fish?

Fish populations do not recognize human imposed geographic boundaries and will freely migrate from one area that is within the former Klamath Reservation boundary to another area outside the boundary, and vice versa. To the fish, there is no Klamath Reservation boundary, just as there is no Forest Service boundary or boundary between California and Oregon. Fish simply do not recognize human imposed boundaries on a map, unless they comprise a physical barrier. Absent such a physical obstruction or barrier, it is the biological needs of the fish that dictate when, and to what extent (i.e., where) certain fish will migrate in a stream.

The entirety of two of the Wood River subbasin claims (Claim 669 – Crooked Creek; and Claim 670 – Fort Creek) and all but approximately the uppermost mile of Claim 668 on the Wood River are within the former Reservation boundary. Adfluvial redband trout (and Chinook salmon upon reintroduction) utilize (or will utilize) all three of these streams for spawning (and in the case of fluvial and resident redband trout, for spawning, as well as juvenile and adult rearing), including the upper portions of the Wood River that are beyond the boundary of the former Reservation. Importantly, even the resident populations of redband trout will move in a stream to find habitats meeting their biological needs. Although the distances associated with these movement patterns may be less than those for adfluvial or anadromous (i.e., Chinook) fish, they can still extend beyond the former Reservation boundary. This is especially true for the resident populations whose territorial range overlaps and extends for short distances above and below the former Reservation boundary. The daily and even hourly movement patterns of these fish may take them back and forth across the geographic location of the former Reservation boundary.

89. Which of the Wood River claims are located beyond the boundaries of the former Klamath Reservation?

The mainstem Wood River claim (Claim 668) encompasses the reach from the mouth of the Wood River as it enters Agency Lake/Upper Klamath Lake upstream to the confluence with Annie Creek. The former Reservation boundary is superimposed directly on a large segment of this claimed reach, but the upper approximately 1 mile segment extends beyond the boundary up to the confluence with Annie Creek.

90. Again, why has this claim been included if it is not within the former Reservation boundary?

As just noted, fish populations do not recognize geographic boundaries and may freely migrate from one area that is within the former Reservation boundary to another area outside the boundary, and vice versa to fulfill specific biological needs such as for spawning, foraging for food, or seeking shelter or better water quality conditions. While the distances migrated may be greater for populations that exhibit an adfluvial (movement from a lake to flowing water) or fluvial (movement within flowing water) life history strategy, even resident fish populations will freely migrate within a stream to meet their biological needs. In the process of making these migrations, the fish may move from areas within the former Reservation boundary to spawning, feeding, or refuge areas located in stream segments outside of or that span the former Reservation boundary. Because the Physical Habitat Claims focused on providing for all of the lifestage requirements needed to provide healthy and productive habitats for the treaty target species, the geographic limits of the claims included the streams and stream segments noted above that extended beyond the former Reservation boundary. These claims are every bit as biologically important as those within the former Reservation boundary.

91. Which of the target fish species and lifestages rely on the streams represented in the Wood River claims that are beyond the former Reservation boundary?

Historical or existing information indicates that all six of the target fish species are or were present in the Wood River subbasin, and that at least three of the species (redband trout, bull trout, and Chinook salmon) are or have used segments of the Wood River that are outside of the former Reservation boundary.

92. Please describe the information you relied on for adfluvial and fluvial redband trout that supports the claims that are beyond the former Reservation boundary (i.e., off-reservation claims).

The Wood River (Claim 668), Crooked Creek (Claim 669) and Fort Creek (Claim 670) currently support substantial spawning runs of adfluvial redband trout from Upper Klamath Lake and Agency Lake. The ODFW, in conjunction with several sportfishing groups has been monitoring redband adult abundance/presence in the Wood River system since 1995. During this period, adult redband have been observed at various locations in the Wood River in all nine months in which surveys were completed. I have personally participated in snorkel surveys in the Wood River in October and December 2003 that have included segments of stream both within and beyond the Klamath Reservation boundary and have observed adfluvial redband trout in both segments. The October surveys included a section of the Wood River that was entirely above the Reservation boundary and the upper extent of the claim. The segment extended from its spring origin downstream about 1 mile to the Dixon Road. I observed several large (estimated > 20 inch) adult adfluvial redband trout holding within this segment.

In December, we completed a second snorkel survey that commenced about 100 yards above the Dixon Road and extended downstream to the confluence of Annie Creek, again, a segment that is entirely beyond the Reservation boundary. During this survey I observed adult adfluvial redband trout and numerous redband trout redds (spawning nests); a total of 63 distinct redds were tallied during this survey. The presence of adult adfluvial redband trout and numerous redband trout redds provide clear evidence that fish utilize all segments of a stream and that the Physical Habitat Claims should not be arbitrarily constrained by limits of the Reservation boundary. The adfluvial redbands we observed migrated upstream from Agency Lake/Upper Klamath Lake into the Wood River and through the entire length of Claim 668 to reach the spawning areas we observed.

93. Please describe the information you relied on regarding bull trout that supports the claims that are beyond the former Reservation boundary (i.e., off-reservation claims).

Bull trout likewise were historically present within the Wood River drainage (Buchanan et al. (1997) citing as documentation: a 1927 photograph of a bull trout caught in the Wood River; reports of bull trout being caught in the Wood River in 1938 (as cited in Dambacher et al. (1992)); and a 330 mm specimen from Fort Creek that was captured in 1876 and presently resides in the Smithsonian Institute). Today, bull trout have been found in the upper 6.2 miles of Sun Creek that is a tributary to Annie Creek but entirely outside of the former Reservation boundary. The USFWS has recently finalized the extent of ESA bull trout critical habitat in the Upper Klamath Basin (USFWS 2004). The list includes Agency Lake and Sun Creek. The designation of Agency Lake as ESA critical habitat is noteworthy since it is the water body that receives the flow of the Wood River. Its inclusion as critical habitat suggests that as bull trout recovery actions in the basin improve habitats, and as bull trout populations grow, a variety of life history strategies (e.g., fluvial, adfluvial) will likely be expressed that lead to at least seasonal utilization of lacustrine habitats in Agency Lake and adjacent streams (USFWS 2004). This means that the populations that presently exist in Sun Creek may over time begin to migrate downstream to and seasonally use habitats in lower portions of the drainage. Given that Sun Creek flows into Annie Creek which flows into the Wood River, it is my opinion that bull trout historically used and will in the future again utilize segments of the mainstem Wood River that are both within and upstream (i.e., above the former Reservation boundary) of the claimed reach.

94. What information did you rely on for Chinook salmon that supports these off-reservation claims?

As I noted in Reiser et al. (2001), Chinook salmon are not currently present within Upper Klamath or Agency lakes or their tributaries, including the Wood River system. However, historic reports and Dr. Hart Direct Testimony at questions 19 through 47 and 54 through 61 indicate that the species was present in the Wood River before the construction of impassable dams downstream of the lakes (Hamilton et al. 2005; Fortune et al. 1966; Logan and Markle 1993). Hamilton et al. (2005) concluded, "The Wood River has and continues to have suitable water quality and physical habitat to support anadromous salmonids. Without the presence of fish passage barriers, salmon undoubtedly inhabited this watershed." Given my observations of the type and quality of habitat present within the Wood River, and my knowledge of Chinook salmon life histories and habitat requirements, I concur with this statement, and moreover it is my opinion that Chinook salmon, like redband trout and bull trout, would have used (and upon reintroduction will again use) the entire reach of the Wood River and would not have been constrained by former Reservation boundaries.

95. You mentioned temperature as being an especially important habitat component. Please explain how and why water temperature is important for fish habitat generally, and specifically its importance in streams within the Wood River subbasin.

Water temperature is one of the most significant water quality parameters in streams; it affects rates of chemical and biological processes and is critical to the survival, metabolism, reproduction, growth and behavior of salmonid fishes and other aquatic biota (Welch et al. 1998). Water temperatures that are too warm or too cold have been reported to influence the migration timing of salmonids and may result in delays (Hallock et al. 1970; Bjornn and Reiser 1991). Further, in a broad study, Rieman and Chandler (1999) concluded from their analysis of temperature data from 581 sites containing bull trout that 95 percent of the observations of juvenile bull trout were made in waters with summer temperature maxima less than 18°C, and most were from waters with summer maxima temperatures less than 14°C.

Over the past 15 years of my studying the streams in the Klamath River Basin, I have noted on many occasions that life functions of fish including those related to their migration, spawning, feeding, and growth are influenced by water temperatures. In fact, many biological functions are triggered by stream temperature. For example, the migration and spawning of Lost River, shortnose, and Klamath largescale suckers all occur within a specific range of temperatures. Likewise, redband trout and bull trout spawning is linked to temperature conditions, and as well the duration of the egg incubation period is dependent on the prevailing temperatures; in general, the colder the temperatures, the longer the incubation period, provided the range of temperatures are within those tolerable for the developing eggs. Bull trout are of special significance in that its temperature requirements are generally the lowest of the fish species present in the Upper Klamath River Basin.

In addition, the adfluvial redband trout in the basin have likely evolved around and are attracted to coldwater areas for spawning and juvenile rearing.

Water temperature also directly influences the survival and growth of fry and juvenile salmonids as well as other fish species. Salmonids and other fish species have evolved around and prefer certain ranges of temperatures that are conducive to their growth and health. Sustained, elevated temperatures beyond these ranges increase stress on fish and render the fish more susceptible to disease outbreaks. For example, warm water temperatures were considered to be at least a contributing factor in the outbreaks of columnaris (bacterial disease of the gills) and Ceratomyxa shasta (digestive system parasite) in fishes in the lower Klamath River that resulted in large fish kills in 2002 (Guillen 2003a; Guillen 2003b; CDFG 2003). As I have described, temperature was an underlying consideration of the Physical Habitat flow claims for the spring-dominated streams and those runoff-dominated streams located downstream. Streams in the Upper Klamath Basin possess a certain temperature regime signature within which fish populations have evolved and become accustomed to. Protection of these thermal characteristics will be important for maintaining the streams' future health and productivity for fish.

96. Can the amount of flow in a stream influence its temperature?

Yes. There have been many studies that have shown this. There are a variety of means to assess water temperature changes in response to changes in flow and affects on fish, such as the deployment and monitoring of continuous recording water temperature gages, modeling of water temperature; flow relationships via computer models (e.g., Stream Network Temperature Model SNTEMP (Theurer et al. 1984); Stream Segment Temperature Model (SSTEMP)

(Bartholow 1995) and others), and most recently the use of Forward Looking Infrared (FLIR) and Thermal Infrared Techniques (TIR) under a variety of flow conditions (Torgensen et al. 2001).

97. Did you use any such resources in the streams of the Upper Klamath Basin?

Yes. We relied on the results of ODEQ's Forward Looking Infrared (FLIR) imaging and TMDL assessment from which to assess temperature concerns and issues. Specifically, we reviewed the FLIR imaging of various stream segments to determine the extent to which the thermal influence of spring dominated streams extended within other streams. For illustrative purposes, I have incorporated a FLIR image provided by ODEQ in Section V of my testimony (see Figure V-8 FLIR image of the Wood River, Claim 668).

98. Dr. Reiser, can you explain why the information you just described concerning species life stage habitat needs and their relationship with flow was useful to you.

This information was not only useful, it was critical inasmuch as it formed the technical and biological underpinnings of the Physical Habitat Claims. Establishing flows necessary to provide healthy, productive habitats for target fish species required, first, careful consideration of all major flow-dependent factors that collectively comprise a healthy, productive fish habitat, i.e., careful attention to the eight principles of Naiman and Latterell. As well, establishing flows necessary to provide healthy, productive habitats required an understanding of how such factors change with flow, i.e., consideration of the flow-dependent life history requirements just noted. This information was coupled with habitat and flow data collected from multiple study sites, and then using those data with accepted methodologies and computer models, the Physical Habitat Claims were derived. These final elements are explained in detail in Sections VII and VIII.

V. DEVELOPING INSTREAM FLOW CLAIMS

99. Dr. Reiser, are you familiar with the methodologies and techniques used in your field to establish a relationship between the physical habitat available to fish and the amount of stream flow in a stream?

Yes. The methodologies and techniques used to establish a relationship between the physical habitat available to fish and the water flow in a stream have been the primary focus of my career as a fish biologist. I am very familiar with methodologies and techniques to establish a fish habitat:flow relationship. Further, I have had the first-hand opportunity to review, refine, and/or apply many of those methodologies and techniques. The methods and techniques that I have applied in the context of this adjudication have involved application of scientifically accepted and recognized techniques. Further, in the course of selecting and applying the methods and techniques used, I also considered a number of other available methods and techniques.

Since the 1970s, many different methodologies and models have been developed and used for quantifying fish habitat and formulating instream flow recommendations for aquatic biota. Wesche and Rechard (1980), Morhardt (1986), Stalnaker and Arnette (1976), the proceedings of the Symposium on Instream Flow Needs (Orsborn and Allman eds. 1976), and the Instream Flow Council (Annear et al. 2004; Locke et al. 2008) each reviews and provides an opinion on most of the instream flow methods commonly applied today. Throughout the process of formulating the Physical Habitat Claims here, I relied upon and considered those opinions and reviews in selecting, applying, analyzing, and reviewing the methods for application for streams in the Upper Klamath Basin.

100. Please describe the methods available to establish a relationship between fish habitat and streamflow.

Some of the more commonly applied methods that fish biologists often consider or apply in an instream flow analysis include the Oregon Method (Thompson 1974); the Tennant Method (otherwise known as the Montana Method) (Tennant 1975); Wetted Perimeter method (Nelson 1980); R-2 Cross Sag Tape Method (Espegren 1996); and the Instream Flow Incremental Methodology (IFIM), along with the companion computer software program called **P**hysical **Hab**itat **Sim**ulation (PHABSIM) (Bovee 1982; Milhous et al. 1984). The IFIM/PHABSIM method is the most prevalent and commonly applied of instream flow methods on which to base instream flow recommendations (Reiser et al. 1989; Annear et al. 2004).

101. Please describe the criteria that you considered in selecting the techniques and methodologies to be applied to your instream flow work in the Upper Klamath Basin.

In determining which methods would be most appropriate for the instream flow claims for the streams in the Upper Klamath Basin, I considered the following criteria:

1. the predictive capability of the method or model to extrapolate results over a range of anticipated flows;
2. the number of life stages considered in the method (e.g., spawning, fry, juvenile, passage);
3. the biological soundness of the methodology results (i.e., habitat-flow relationship curves and criteria that relate directly to the fish species present in the Upper Klamath Basin);
4. the applicability of the methodology to different fish species including resident and anadromous salmonids;

5. the sensitivity of method/model output to individual user (i.e., ability to control bias);
6. the reproducibility of results;
7. the ease of field data collection and analysis;
8. the validity of results (known linkages between habitat-flow-fish population relationships demonstrated);
9. the acceptability of the method/model for use in the State of Oregon;
10. the history of successful application of the method in Oregon and elsewhere; and
11. whether the method has been court tested.

Consideration of the above selection criteria and the size and complexity of this project resulted in the selection and use of the IFIM/PHABSIM method, in all areas where applicable, for collecting and analyzing habitat and flow information and formulating the instream flow claims. Application of the IFIM/PHABSIM method provided for the derivation of species and lifestage specific habitat:flow relationships that allowed for not only the determination of Physical Habitat Claims for a specific target species, but also a comparative assessment of how the claim flows might affect other target species and lifestages.

102. Please describe in general terms the IFIM/PHABSIM method.

The IFIM/PHABSIM methodology comprises both hydraulic and habitat models which, when interfaced, provide a means of estimating fish habitat as a function of stream flow (Milhous et al. 1984; Bovee 1982). The methodology employs hydraulic simulation models so that habitat can be incrementally projected with streamflow. As already described, this predictive quality of the methodology was considered important relative to determining the amount of flow needed to provide for healthy and productive fish habitat. The IFIM/PHABSIM methodology allows a fish biologist to simultaneously consider multiple flows and multiple flow-dependent factors. Finally, the IFIM/PHABSIM represents a recognized method for use by the Oregon Water Resources Department (see OAR 690-028-0027(2)).

103. Are you aware whether the Oregon Water Resources Department (OWRD) has recognized any habitat:flow technique and methodologies?

Yes. As I previously mentioned, OWRD has recognized the IFIM/PHABSIM methodology, and in fact has recognized several methods for determining instream flows. OAR 690-028-0027(2). States specifically that:

> A claimant shall provide supporting documentation of the methods used to estimate water quantities needed to satisfy the purpose or purposes of the reservation. Accepted methodologies for determining habitat needs include, but are not limited to:
>
> (a) Instream Flow Incremental Methodology habitat suitability curves published in a series of technical reports by the U.S. Fish and Wildlife Service;
>
> (b) The Oregon Method developed by the Oregon State Game Commission (Thompson, K.E., 1972, determining streamflows for fish life, pp. 31-50, in Proceedings of the Instream Flow Requirement Workshops, Pacific N.W. River Basins Commission, Portland, OR);
>
> (c) Forest Service Method developed by the Pacific Northwest Region USDA Forest Service, (Swank, G.W. and Phillips, R.W. 1976, Instream Flow Methodology for the Forest Service in the Pacific Northwest Region, pp. 334-343, in Proceedings of Symposium and Special Conference on Instream Flow Needs, Orsborn, J.F. and O.H. Allman, eds. Vol. II, American Fisheries Society, Bethesda, MD); and
>
> (d) Environmental Basin Investigation Reports conducted by the Oregon State Game Commission between the mid-1960's and the mid-1970s.

104. So, there are four specific methods that OWRD recognizes?

Yes. However, the OAR notes the four are not the only methods that can be applied. Thus, there is flexibility in the selection and application of a method based on project-specific conditions and study objectives.

105. The OAR mentions the Oregon Method. Please briefly describe that method and explain why you did not use it on this project?

The Oregon Method was developed by fish biologists from the Oregon State Game Commission (now ODFW) in the 1970s as a means to define instream flows that considered several important life history stages of fish, including spawning, juvenile rearing, and fish passage (Thompson 1972). For spawning, water depths and velocities are measured at different flows along transects placed across several spawning gravel bars. The percent of each transect meeting specified depth and velocity criteria is then determined for each flow. Results are averaged for all transects and plotted against the measured flows. The optimum spawning flow provides suitable depths and velocities over the maximum amount of spawning area within the stream. A minimum flow corresponds to the inflection point where flow increases provide less than a proportionate gain in habitat, and flow reductions result in a greater than proportionate decrease in habitat.

For rearing, a similar approach to defining spawning flow is used; this approach involves the measurement of velocities across selected riffle areas at different flows. Fish passage requirements are evaluated by comparing water depths and velocities provided by a given flow with fish body dimensions (in terms of depth) and swimming capabilities (in terms of velocity).

Although similar in principle to the IFIM/PHABSIM approach, in that a relationship of habitat area versus flow can be developed, the Oregon Method does not explicitly involve any hydraulic or habitat modeling that allows for the extrapolation of flows beyond those measured in the field. Thus, the habitat-flow relationships derived from the Oregon Method are limited to a relatively narrow range of flows that are empirically measured in the field. For that reason, we elected not to use the Oregon Method for this project.

106. The OAR also lists the Forest Service Method of Swank and Philips (1976). Can you describe that method and explain why you chose not to use it?

The Forest Service Method, which is also known as the USFS R-6 Method (Wesche and Rechard 1980) was developed by Swank and Phillips (1976) as a means to determine the optimum flow for fisheries purposes. In this case, Swank and Phillips (1976) defined the optimum flow as the one that provided the greatest amount of usable habitat in terms of spawning, rearing and food producing area. The method requires the establishment of cross-channel transects (depths and velocities) within representative habitats, that are measured at various intervals across the transect under at least three flow conditions. The useable width of each cross section is determined for each flow based on spawning, rearing, and food producing criteria, and graphical plots of the results are developed, from which the optimum flow is determined.

This method does not involve the development of hydraulic models to allow extrapolation of flow-habitat relationships and is therefore limited to the range of flows empirically measured in the field. In addition, the method does not consider individual differences in species relative to the lifestage criteria so that resulting flow recommendations are presumed to be suitable for all species. Because of these limitations and that we were concerned with different species and multiple life history stage, we did not use the Forest Service Method to derive any of the Physical Habitat flow claims.

107. The OAR also lists the Environmental Basin Investigation Reports that were completed by the Oregon State Game Commission during the mid-1960s and mid-1970s. Can you describe that method and explain why you chose not to use it?

The reference to the Environmental Basin Investigation Reports refers to a series of reports that were prepared by Oregon State Game Commission (OSGC) biologists for all of the major basins in Oregon. The Klamath River Basin was one of these, with the report published in 1970 (Thompson et al. 1970). The report provides an overview of the fish and wildlife resources in the Klamath Basin, describes the biological requirements of trout, discusses factors affecting the fish resources, presents the results of an instream flow study conducted on major streams within the basin, and provides a summary table of monthly instream flow recommendations. The actual development of the instream flow recommendations was based on the Oregon Method, which, as I explained above does not allow for extrapolation of flows beyond those measured in the field and for that reason was not used. However, the Basin Investigations for the Klamath Basin (Thompson et al. 1970) contain useful information related to many of the streams in the Wood River subbasin and was used as a reference. Moreover, the instream flow recommendations developed by the OSGC for a given stream and listed in the report were subsequently compared with the Physical Habitat Claims in the Wood River subbasin presented in this testimony for the same streams.

108. You also mentioned the Tennant/Montana method as a common method used by fish biologists to determine instream flows. Please briefly describe that method and why you did not use it.

The Tennant/Montana method (or Tennant method) is a useful method when access restrictions along a claim reach prevents the gathering of stream data. I employed the Tennant method in a few instances in the Upper Klamath Basin when we could not secure property owner permission to gather data necessary to employ the IFIM/PHABSIM method (specifically Claim Reach 633 associated with case #277 of the Klamath River Basin Adjudication and Claim Reach 654 associated with case #280 of the Klamath River Basin Adjudication). We did not have access restrictions associated with the Claim Reaches of the Wood River and employed the IFIM/PHABSIM method for each claim reach (Claim Reaches 668 through 670).

The Tennant method was developed by Donald Tennant in 1976 (Tennant 1976) and is still a widely applied method for establishing instream flows for broad scale studies and regional planning efforts. The State of Alaska Department of Fish and Game (ADFG), for example uses the Tennant method extensively for developing instream flow recommendations for applying for instream flow water rights (Estes 1996). The Tennant method is based on the premise that the flow of a stream is a composite manifestation of characteristics such as drainage area, geomorphology, climate, vegetation cover, and land use. It can be used with limited or extensive hydrological and fishery data. In general, the method relies on eight flow classifications with each assigned a percentage or percentage range of the average annual flow (QAA) (Table V-1). The percentages are typically applied to specific times of year with the year divided into two six-month periods, April through September and October through March. In the case of the Upper Klamath River Basin, we selected percentages based on lifestage priorities, with higher percentages (50% QAA) ascribed for periods during spawning, and lower percentages (30% QAA) during periods of Adult and Juveniles. This approach of aligning the percentages of QAA based on life stage use has likewise been applied by the ADFG (Estes 1996). Seven of the Tennant classifications characterize habitat quality for fish and the eighth provides for a flushing flow which focuses on cleaning (flushing) fine sediments from spawning gravels. The percentage of QAA for habitat quality range from less than 10 percent (Severe Degradation) to 60 percent - 100 percent (Optimal Range).

Table V-1. Instream flow regimes for fish habitat (Tennant 1976). The Physical Habitat Claims developed for streams in the Upper Klamath Basin employing the Tennant method were based on 50% of QAA during periods of spawning and 30% of QAA during periods of adult and juvenile rearing.

Narrative Descriptions of Flows	Base Flow Regimes (QAA)	
	Oct. – Mar.	Apr. – Sept.
Flushing Flow	200%	200%
Optimal Range	60-100%	60-100%
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair	10%	30%
Poor or Minimum	10%	10%
Severe Degradation	10%	10%

109. You also mentioned the Wetted Perimeter Method as a common method used by fish biologists to determine instream flows. Please briefly describe that method and why you did not use it.

This method was developed as a way to approximate fish habitat via the measurement of a few cross sectional parameters. Wetted perimeter is the length of the channel bottom that is wetted (i.e., in contact with water) as measured from one side of the channel to the other (Nelson 1980). Wetted perimeter changes with flow. Typically with this method, the analyst selects an area (typically a shallow riffle) as an index of habitat for the rest of the stream. When a riffle is used as the area, the assumption is that a minimum flow for that site would satisfy the needs for food production, fish passage, and spawning. The method generally results in a "minimum flow" recommendation that would be in effect year round, rather than a temporally variable set of flows as developed via PHABSIM. Because this method did not provide variability based on lifestages, we did not use this method for developing the Physical Habitat flow recommendations.

110. Finally, another method you mention as commonly applied is the R2 Cross Sag Tape method. Please describe that method and why you did not use it.

The R2 Cross Sag Tape method was originally developed in Region 2 (Rocky Mountain States) of the U.S. Forest Service (Rose and Johnson 1976 (281-US-403)). The method involves the placement of one or more transects across riffle habitats across which water depth and water velocity data are collected. These data are input into a computer model, which is called R2-Cross, which computes average depths and velocities across the channel at each of the measured flows. These values are compared with depth and velocity criteria designed to meet critical habitat needs such as food production, juvenile rearing, or passage. The flow that meets a certain amount or percentage of the criteria becomes the recommended flow. This method has been used extensively in the Rocky Mountain States for establishing minimum flows. However, the method is not species or lifestage specific and does not directly compute habitat:flow relationships that can be used in developing monthly flow recommendations. Like the wetted perimeter method noted about, the R2 Cross method generally results in a "minimum flow" recommendation that would be in effect year round, rather than a temporally variable set of flows as developed via PHABSIM. For these reasons, we did not use this method for developing the Physical Habitat Claims.

111. Turning to your applications of the IFIM/PHABSIM, please describe any physical features that affected such application.

As in most river basins, the quantity of flow in the streams of the Upper Klamath Basin typically changes over time. The rivers and streams in the Upper Klamath Basin also present unique hydrologic features. Possibly unlike any other major river basin, the streams of the Upper Klamath Basin involve a complicated mixture of both runoff water (waters that end up in a stream from snowmelt or recent rain events) and spring water (water that percolates to the surface from distant or unknown underground sources which are not directly tied to recent precipitation events).

A pattern to these flows exists and can be seen in the hydrograph of the system. Two general patterns of stream flow are evident: runoff-dominated streams and spring-dominated streams. Runoff-dominated and spring-dominated streams are explained in greater detail in the Mr. Ramey Direct Testimony at questions 4 and 52.

Three of the four major subbasins that drain the Upper Klamath Basin – the Williamson River, the Sprague River, and the Sycan River - contain reaches and tributaries that are dominated by runoff and dominated by springs. The fourth subbasin, the Wood River system consists primarily of spring-dominated streams. The runoff stream flow pattern is influenced primarily by the amount of snow that has fallen in the watershed over winter months and the resulting magnitude and timing of snowmelt runoff from the mountains. In runoff-dominated streams, the amount of flow in the stream typically increases substantially and reaches a peak during the spring months (generally sometime between February and June) in response to snowmelt runoff. As the amount of snow decreases, so too does the amount of flow in the stream. This results in a pattern of declining flows during the summer and fall months until reaching a base-flow condition. Base-flow conditions are generally marked by a condition of relatively low, stable flows that are the product of waters emanating from precipitation and groundwater infiltration to the stream. Base-flow conditions typically occur in the late fall (October/November) and winter months (generally, between October and February).

By contrast, the flow in the spring-fed stream is controlled primarily by the release of water emanating from underground springs and is largely independent of the amount of snow that has accumulated in the respective basins. These types of spring-dominated streams are characterized by having stable flows that remain relatively constant throughout the year.

112. Are there differences in the physical, chemical and biological characteristics between runoff- and spring-dominated streams, and if so, can you describe them?

Yes. The two different patterns of flow have created widely different and unique habitat characteristics in some of the streams in the Upper Klamath Basin that are relied upon by certain target fish species. Both runoff- and spring-dominated streams are important in providing healthy and productive habitats for the target fish species. The constant flow, cool water temperatures, and high water quality of spring-dominated streams make them uniquely important for salmonid (trout and salmon species) populations. Publications, field reports and observations conclusively establish that adfluvial populations of redband trout from Upper Klamath Lake utilize a number of spring-dominated streams for spawning and juvenile rearing including the Wood River (Claim 668), Crooked Creek (Claim 669), and Fort Creek (Claim 670) in the Wood River subbasin; and Larkin Creek (Claim 634) and Spring Creek (Claim 640) in the Williamson River subbasin.

Further, a comparison of annual flow and temperature patterns between representative runoff-dominated and spring-dominated streams illustrate major differences in annual flow and temperature cycles (Figures V-1 and V-2). The graphs illustrate the flow and temperature regimes of the runoff-dominated stream (Figure V-1 – Long Creek – Claim 665) are much more variable than the spring-dominated stream (Figure V-2 – Fort Creek – Claim 670). For a spring-dominated stream, the monthly flows and temperatures are quite similar throughout the year. This is evident in the constancy of the mean monthly flows and the similarity in the ratios of the 5 percent, 95 percent and 50 percent (median) exceedance flows normalized to mean monthly flow. On the other hand, the runoff-dominated stream (Figure V-1) displays substantial variation in both mean monthly flow and the normalized ratios.

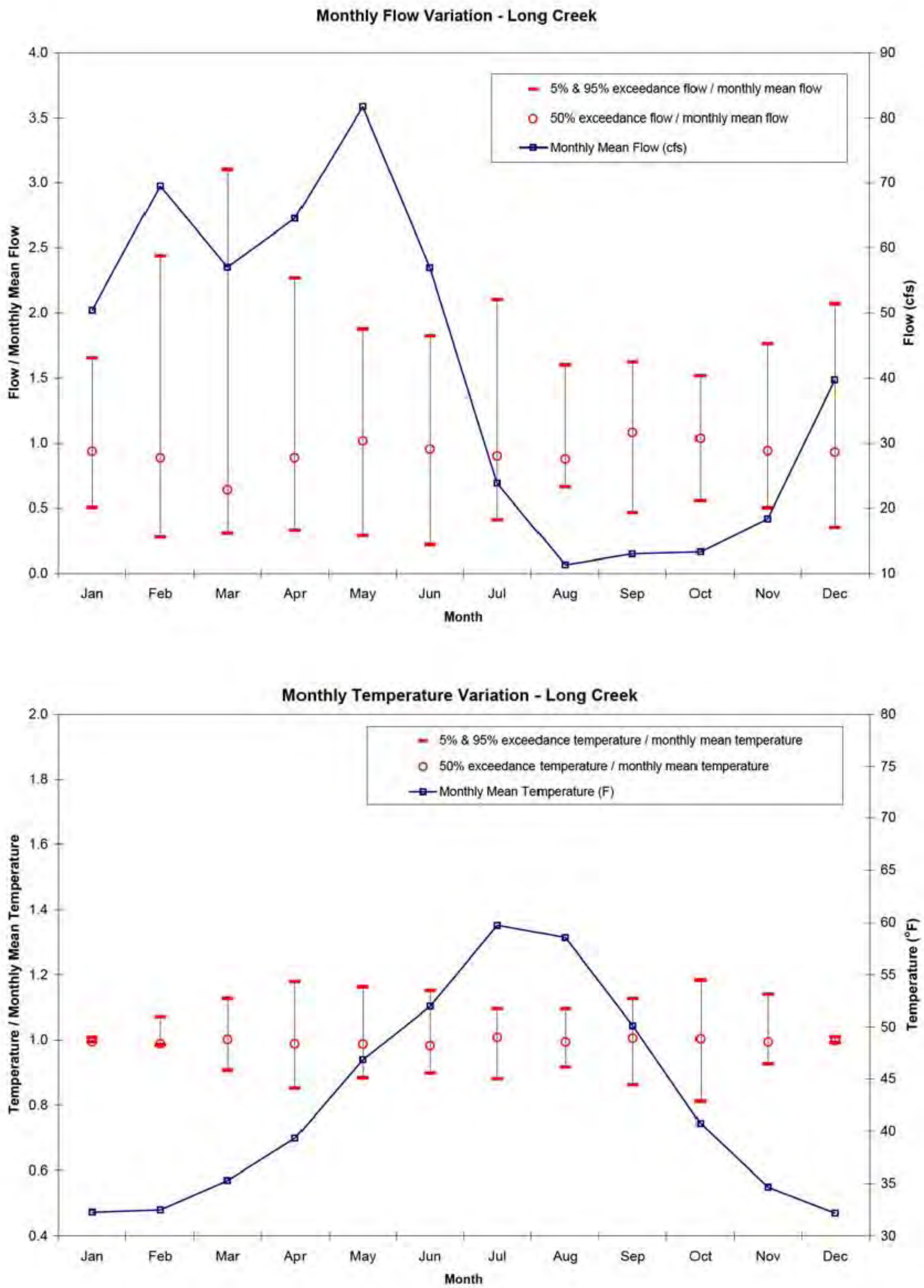
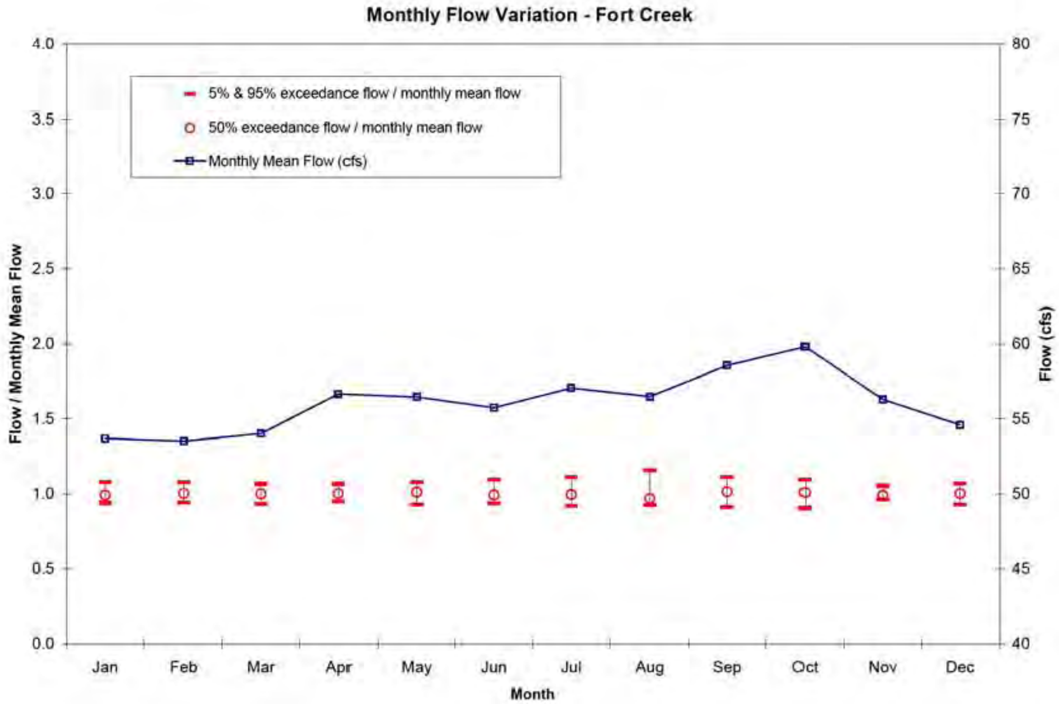


Figure V-1. Mean monthly flow and flow variation (Figure V-1a) and mean monthly temperature and temperature variation (Figure V-1b) for Long Creek (Claim 665), a run-off-dominated stream located in Upper Klamath Basin, Oregon.



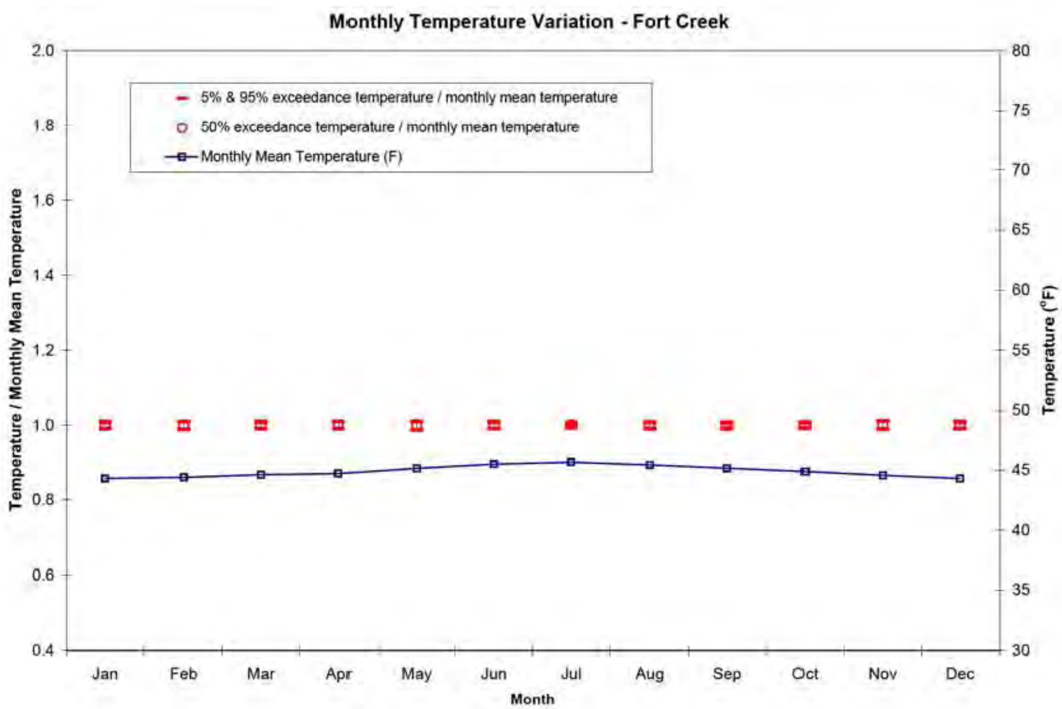


Figure V-2. Mean monthly flow and flow variation (Figure V-2a) and mean monthly temperature and temperature variation (Figure V-2b) for Fort Creek (Claim 670), a spring-dominated stream located in Upper Klamath Basin, Oregon.

Finally, two schematics illustrate some of the more notable physical differences between spring-dominated and runoff- dominated streams (Figures V-3 and V-4). In addition to flow and temperature constancy, spring-dominated streams also often contain abundant aquatic macrophytes (aquatic plants), uniquely arranged woody debris aligned perpendicular to the banks, rectangular, wide, and uniform channel shape, stable channel banks, abundant aquatic insects, and high water clarity. Each of these physical differences is an important component of a healthy and productive environment in the spring-dominated streams of the Upper Klamath Basin and those runoff-dominated streams downstream of the spring-dominated streams.

All of the streams for which claims were made in the Wood River subbasin were designated as spring-dominated and have their origins in one or more springs that essentially mark the beginning of the stream. The Wood River (Claim 668; Figure V-5) has its origin from a series of large springs that are located within the Jackson Kimball State Park. Crooked Creek (Claim 669; Figure V-6) arises from a series of springs within that drainage including several large springs used as part of ODFW's State Fish hatchery operations, as well as Tecumseh Springs which is a small tributary to the Crooked River. Fort Creek (Claim 670; Figure V-7) likewise originates from a large springs named Reservation Springs that provides the majority of flow in that stream. These types of spring-dominated streams can have a direct positive effect on the flow and temperature regime and associated biota of downstream systems. Both Fort Creek and Crooked Creek influence the flow and temperature regime in the Wood River. The flow of the Wood River provides the major supply of coldwater to Agency Lake (that connects to Upper Klamath Lake) during the warm summer months, and represents important coldwater habitat for target fish species during these periods. The coldwater temperatures of the Wood River system were evident in the aerial thermal mapping images depicted in Figure V-8. The image depicts water temperatures of around 9-10°C that occurred in August 1999 near the study site for Claim 668 adjacent to the USFS Day-use area. For comparison, temperatures within the lower Sprague River measured during the same time were 18-20°C (see Figure IX-626-4).

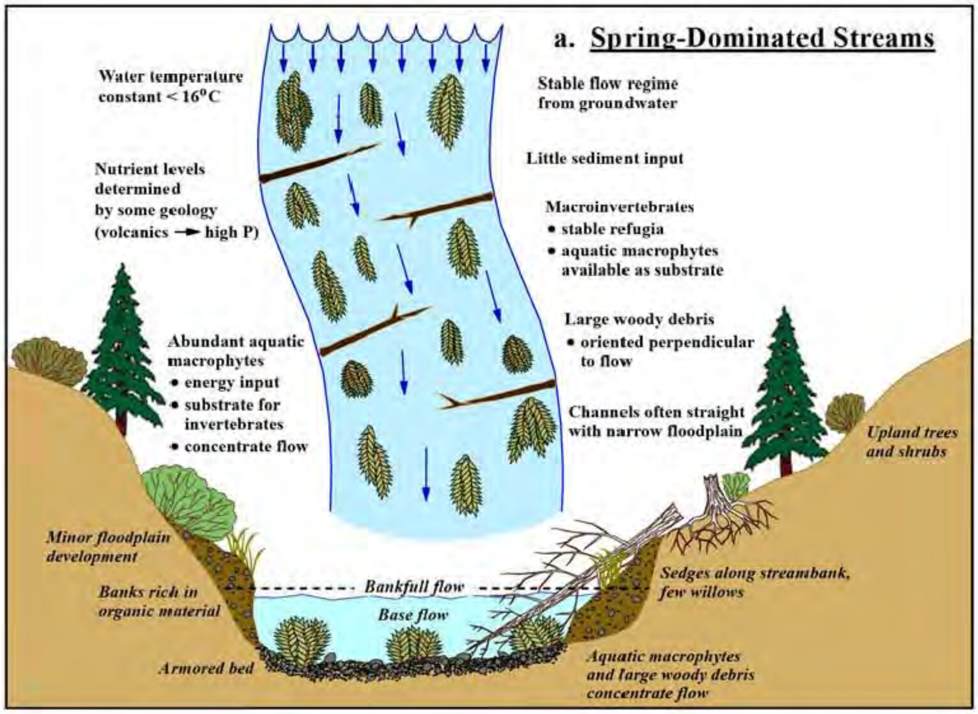


Figure V-3. Schematic planform and cross-section of a typical spring-dominated stream depicting representative channel and geomorphologic characteristics.

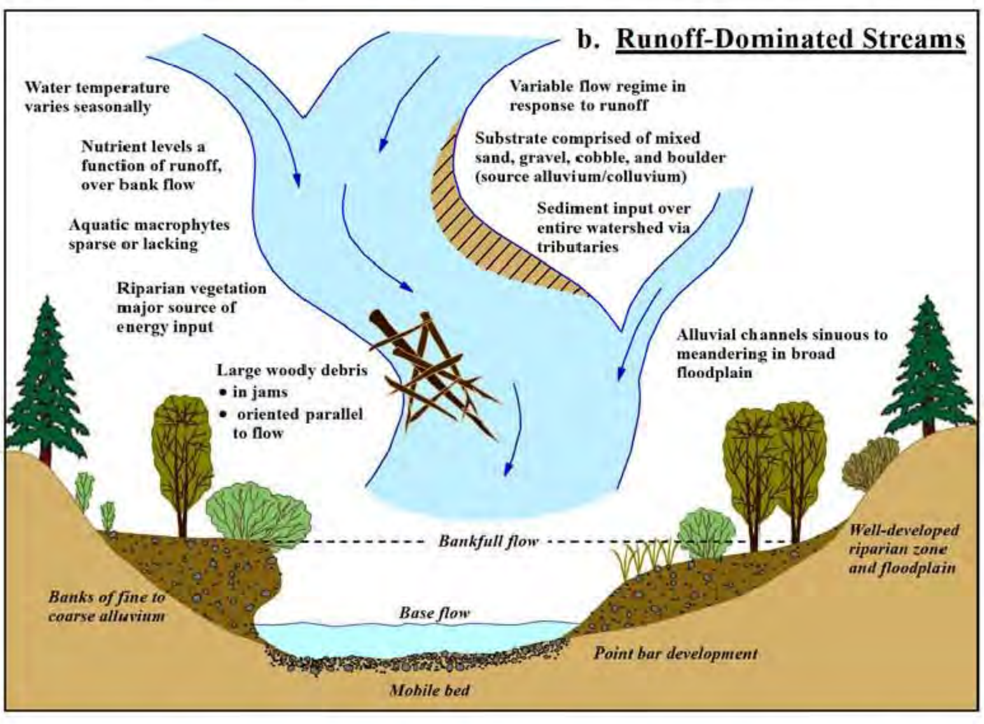


Figure V-4. Schematic planform and cross-section of a typical runoff -dominated stream depicting representative channel and geomorphologic characteristics.

Figure V-5a and 5b. Photographs of the Wood River (Claim 668) near U.S. Forest Service access area; photos are (Figure 5a) (upper photo) upstream view from lower end of access area; (Figure 5b) (lower photo)downstream view from upper end of area. Photos taken September 1, 2004.

Figure V-6a and 6b. Photographs of Crooked Creek (Claim 669) just below Oregon Department of Fish and Wildlife Hatchery. Spring source is located about 100 m upstream. Figure 6a (upper photo) depicts downstream view and illustrates riparian vegetative types characteristic of spring-dominated streams. Figure 6b (lower photo) depicts upstream view and shows spawning gravels in center of channel Photos taken September 1, 2004.

Figure V-7a and 7b. Photographs of Fort Creek (Claim 670) located approximately 500 meters downstream of the spring source (flow is from upper to lower) (upper photo) (Figure V-7a). Note the large woody debris oriented perpendicular to the channel indicating stable flow conditions. Figure V-7b (lower photo) depicts Fort Creek just below Reservation Springs. Photos taken September 1, 2004.

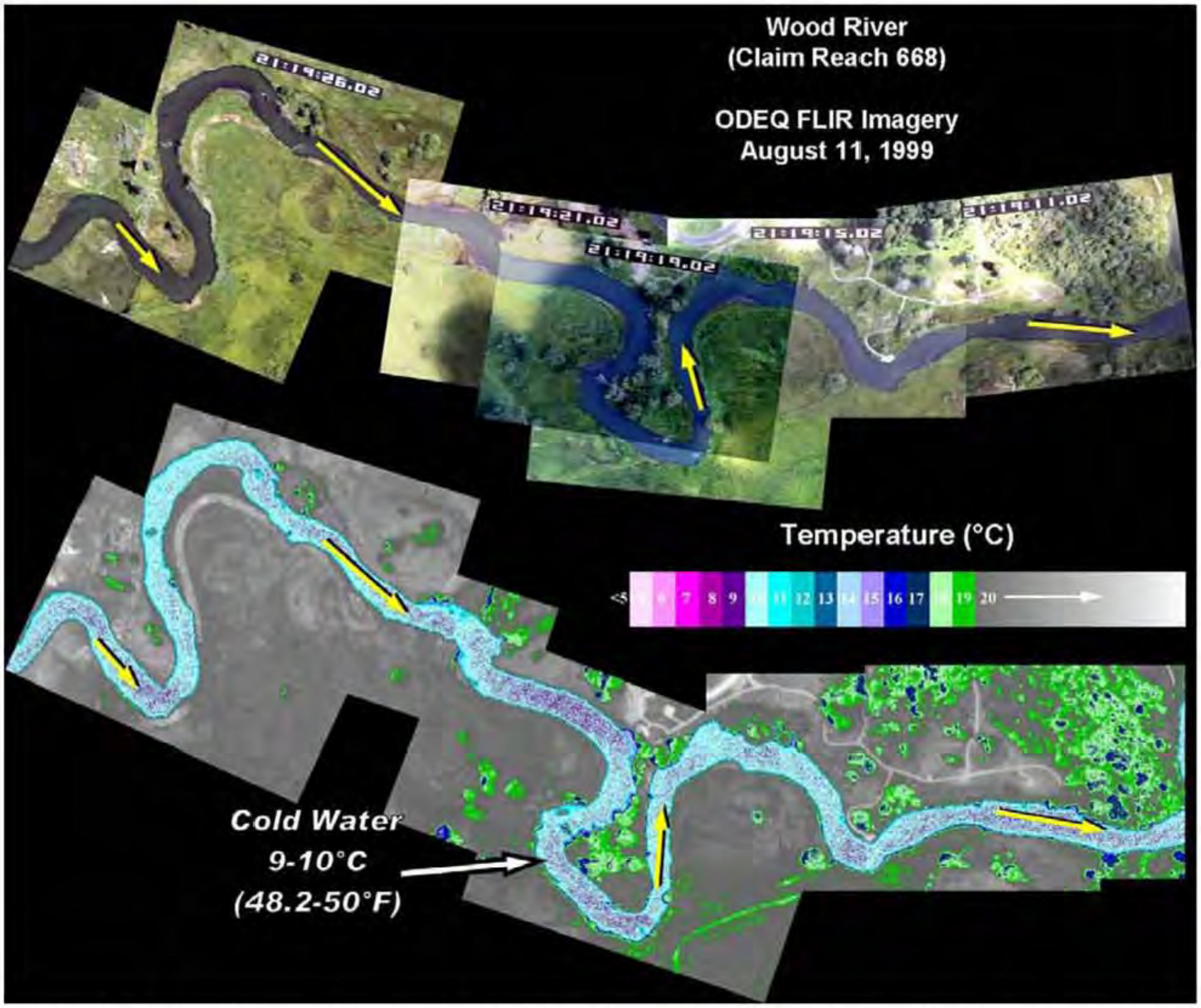


Figure V-8. FLIR image (on bottom) and natural image (on top) of a segment of Claim Reach 668 on the Wood River located near USFS day-use area. The colored bands apparent in the photograph represent different temperatures. Water temperatures throughout this segment of the Wood River were in the range of 9-10°C. The Wood River represents the major source of coldwater to Agency Lake during the warm summer months.

113. Did the distinction between runoff-dominated streams and spring-dominated streams affect your application of instream flow methodologies?

Yes. As I explain further in Section VIII, in developing the hydraulic simulation models for runoff-dominated streams where flows differ throughout the year, three sets of flow measurements are typically collected representing a low flow, medium flow and high flow condition in the stream; this allows for a relatively wide flow extrapolation range (the range of flows which can be predicted lower than or higher than the flow that was measured in the field). With spring-dominated streams, flow conditions are generally stable so only one set of flow measurements is needed. Although the resulting range of extrapolation is narrower, with relatively constant flows, a broader range of extrapolation was simply unnecessary. Also, I necessarily gave additional consideration to the special qualities and unique characteristics imparted by the spring-dominated systems, including the provision of coldwater to downstream reaches.

114. In your opinion, is it appropriate to apply the IFIM/PHABSIM method both to runoff-dominated streams and spring-dominated streams?

Yes. IFIM/PHABSIM is completely applicable for developing habitat:flow relationships for both spring-dominated and runoff-dominated systems. In a recent peer reviewed publication (Reiser et al. 2006), I specifically described how the IFIM/PHABSIM method could be applied to both spring-dominated and runoff-dominated streams. I followed that approach here.

115. You mentioned spring-dominated streams as having unique flow characteristics that you considered when developing the Physical Habitat Claims. Were there any others?

Yes. Several biotic and abiotic flow related components unique to spring-dominated streams and streams with significant spring contribution exist that are important ingredients to a healthy, productive habitat. These include water temperature within tolerance ranges for target fish species, riparian vegetation of sufficient quality, and aquatic invertebrates in sufficient quantity. Each component is independently affected by streamflow and each component must exist to provide for a healthy and productive habitat.

116. Have you observed land-use practices in the UKRB that might result in increases in water temperature?

Yes. I have observed streams that have lost their riparian canopy as a result of land-use practices in the Upper Klamath Basin including the Wood subbasin. Lost riparian canopy results in increased solar input (heat) to the stream and hence can result in the warming of the stream. Flow diversions from irrigation withdrawals can render them even more vulnerable to warming.

117. Can the amount of flow in a stream influence its temperature?

Yes. Lower stream flows can cause increased stream temperatures. As I have described in Section IV, we relied on the results of ODEQ's FLIR imaging (see Figure V-8) and TMDL assessment from which to assess temperature concerns and issues.

118. Were there any other factors you considered important when developing the Physical Habitat Claims?

Yes. I also considered riparian vegetation. Although this is discussed in much greater detail in Dr. Chapin Direct Testimony at question 19, I can provide a general description of the importance of the riparian environment to maintaining an overall healthy and productive fish habitat.

By riparian vegetation and riparian environment, I am referring to the vegetative communities that border streams and rivers. These communities provide important elements to a healthy and productive fish ecosystem that substantially contribute to sustained salmon and trout production. Obvious benefits from the riparian environment include stream shading/shielding from solar input (reducing water temperatures), fish cover (via overhanging vegetation), recruitment of both large woody debris and smaller debris (providing structure and cover), input of "leaf litter" (e.g., deciduous leaf fall, conifer needles) and other organic materials (providing nutrient input for invertebrate/food production), bank stability (via decreased erosion), and terrestrial insects (providing significant food supply) (Murphy and Meehan 1991; Platts 1991). There are many land-use activities that can destroy or reduce both the size of and effectiveness of riparian vegetation and the riparian environment. These most notably include livestock grazing, agricultural land development, and logging.

The diversion and reduction of streamflows reduce the vegetative communities (i.e., density, diversity, species composition) within the riparian zone and in some cases result in the complete collapse of the native riparian plant communities (Rood et al. 1995; Scott et al. 1997; Stromberg and Patten 1991). The long-term health of riparian plant communities depends on flood flows to recharge alluvial aquifers, provide sites for seedling establishment, transport and deposit seeds on the floodplain, and replenish nutrients in floodplain soils. Sufficient in-channel flows are often also important for maintaining the alluvial aquifer (an aquifer is a permeable formation that forms naturally and stores or conducts groundwater; an alluvial aquifer is formed by the deposition of weathered materials such as sand and silt particles; the water flow in these aquifers is slow) within or near the rooting zone of riparian plants through the growing season. Riparian species are typically hydrophytic plants (plants that occur in soils saturated or inundated for extended periods during the growing season), and require relatively high levels of soil moisture throughout the growing season, in contrast to adjacent upland plant communities. As a result of the various flow needs of the riparian zone, reduction in the frequency and magnitude of flood flows or reduced in-channel flows can cause the riparian zone to become smaller (both in width and in stature), less diverse, or even eliminated. Negative impacts on the riparian zone in turn have negative consequences for fish habitat. Without the support from the riparian zone described above, fish habitat would be without many necessary components; for example temperatures would be higher, cover would reduced, and trophic inputs would be negatively altered (see Figure V-9).

In sum, without a riparian zone and without the flows to support the riparian zone, only the spatial component of fish habitat as provided in the Physical Habitat Claims will be provided. While the quantity of flow identified in those claims was focused on creating healthy and productive habitats in streams that meet, but do not exceed the spatial needs of the target fish species, it was understood that the flows proffered by the Riparian Habitat Claims were likewise a critical ingredient of healthy and productive habitat and were thus included as a component of the overall tribal instream flow claims.

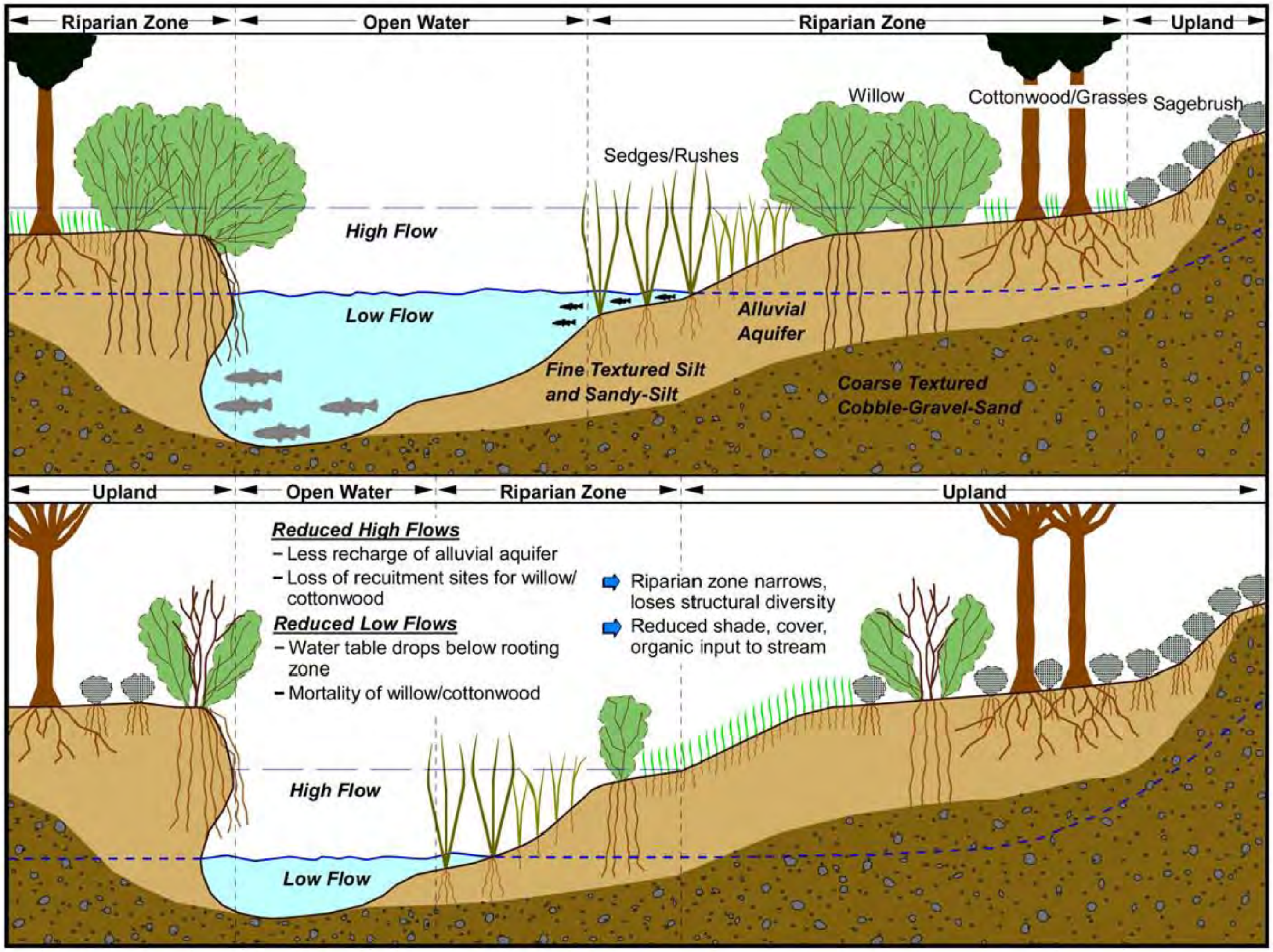


Figure V-9. Conceptual diagram illustrating general effects of streamflow reductions on riparian habitats.

119. Are there any other components of the ecosystem you considered of special importance when developing the Physical Habitat Claims?

Yes. Aquatic invertebrate communities within the streams are another necessary component of healthy and productive habitat for fish. I described above that fish need water to survive; fish also need food to survive. In most streams, and certainly those in the Upper Klamath Basin, the predominant source of food for fish is comprised of organisms that are referred to as aquatic benthic invertebrates. These organisms include flatworms, crustaceans (e.g., crayfish, snails, mollusks), and insects. Insects are most often the most abundant group of aquatic invertebrates residing in freshwater habitats (Hershey and Lamberti 2001; Ward 1992).

120. Are aquatic invertebrate communities affected by flow?

Yes. Flow has both direct and indirect effects on aquatic invertebrates. Many aquatic insects have developed in response to living in the currents (Ward 1992). Flow also has pervasive effects on the ecological processes involving aquatic invertebrates, the most notable effect is probably that of drift (the process by which aquatic invertebrates are transported downstream by flow). Drifting organisms are those most often sought after by fish that are actively feeding and represent those that anglers are continually trying to imitate as part of fly fishing. Streamflows also influence the quality of habitats that are used by aquatic invertebrates by flushing fine sediments downstream and creating new areas of habitation.

121. Did you collect aquatic invertebrate samples from streams in the Upper Klamath River Basin?

Yes. In September 2004, we collected and analyzed aquatic invertebrate samples from representative spring-dominated and runoff-dominated systems. Results of the sampling revealed distinct differences in the species and numbers of organisms found between the two types of systems. Overall, we found that aquatic invertebrate communities in spring-dominated systems had fewer kinds of invertebrates but showed an increased dominance of non-insects in community composition. One of the most dominant non-insect species present in the spring-dominated streams was the "spring snail" (hydrobiid pebblesnail). Because of their unique conditions and often disconnected distribution, spring communities have received increasing attention for representing unique systems harboring rare and endemic species and providing stable conditions for the persistence of these species. In spring-dominated streams, 11 species of pebblesnails (*Fluminicola*) have been found to be endemic to the basin (Frest and Johannes 1995 (Ex 281-US-404); 1996 (Ex 281-US-405); 1998 (Ex 281-US-406)). Three species from the Upper Klamath Basin (the Klamath pebblesnail, tall pebblesnail, and Klamath Rim pebblesnail) have been designated as Record of Decision (1994) Survey and Manage freshwater mollusk taxa under the Northwest Forest Plan (Frest and Johannes 1999).

All hydrobiid snails have gills that make them dependent upon dissolved oxygen in the water in which they live. Hydrobiids are highly sensitive to water pollution, oxygen deficits, elevated water temperatures, and sedimentation. Both the tall and Klamath Rim pebblesnails are crenophiles (i.e., organisms living only in spring environments); whereas the Klamath pebblesnail prefers clear, cold, flowing waters found in spring-dominated streams. Current management recommendations for these taxa are to protect the required environmental conditions at known sites (USDA Forest Service and USDI Bureau of Land Management 1998). Among the activities listed that may impact these environmental conditions were dredging, grazing, nutrient enrichment, water pollution, and decreased water flow as a result of diversion for irrigation or other purposes (USDA Forest Service and USDI Bureau of Land Management 1998).

122. What did you conclude from the information gathered?

The information gathered suggests that the spring-dominated systems in the Upper Klamath Basin represent unique ecosystems that alone and in combination help to sustain native fish populations despite large scale losses of habitat, water withdrawals, and other human induced disturbances. Nightengale and Reiser (2005) (Ex. 281-US-407) showed that the spring-dominated streams of the basin contain unique assemblages of organisms that likely exist due in large part to prevailing stable flow and temperature conditions. This high abundance of organisms in turn supports a food-web for fish capable of supporting year-round fish production. Therefore, the stream flows of these unique systems were considered to be important to providing a healthy, productive fish environment.

VI. CURRENT CONDITIONS OF STREAMS AND TARGET FISH SPECIES WITHIN THE UPPER KLAMATH BASIN

123. Dr. Reiser, can you describe the current conditions of streams and target fish species within the Upper Klamath Basin?

Yes. From a physical habitat or livable space perspective, some of the streams in the Upper Klamath Basin are in relatively good condition while at the same time many others are in relatively poor condition. I describe more specifically the current condition of each reach of the Wood River subbasin streams in Section IX. As to the target fish species, the current opportunity for the Klamath Tribes to harvest target fish species is limited; four of the target species (shortnose suckers, Lost River suckers, Chinook salmon and bull Trout) have been either extirpated or listed as threatened or endangered under the Endangered Species Act and one of the target species, (redband trout), although present in the Basin, is closely managed by the ODFW as a highly regulated sport fishery. As such, none of the populations of the target species are in healthy enough condition to allow harvest activities that would support a commercial fishery, or more than an incidental infrequent subsistence fishery.

124. You just stated that many streams in the Upper Klamath Basis have poor conditions. What contributes to these relatively poor stream conditions?

Just as many components contribute to a healthy, productive fish habitat, a host of components can contribute to undermining fish habitat. Interestingly, although it requires many components in the right combination to ensure a healthy, productive habitat, it is possible for a single negative component to wholly undermine the health and productivity of fish habitat. Both streamflow related factors, such as diversions, and land use practices, such as grazing, can singularly and collectively contribute to poor conditions.

125. You stated that flow-related conditions can contribute to poor fish habitat conditions. Please explain.

Flow-related conditions can contribute to poor fish habitat conditions. Most notably in the Upper Klamath Basin, numerous diversions, primarily for irrigation, occur in streams resulting in significant reductions in stream flow particularly during the hotter summer growing-months when stream flows, especially those of runoff-dominated streams, are typically at their lowest flow levels.

126. How do such reduced flow conditions resulting from diversions impact the health and productivity of the fish habitat?

Diversions can severely reduce and even eliminate the flow of water in a stream. For streams in the Wood River subbasin, this is most evident during the summer irrigation period when stream flows are naturally low. As Figures IV-1 and IV-3 depict in Section IV, reductions in flow can also undermine the survival of eggs in gravels, as well as reduce the amount of spawning and rearing habitats, and food production area in a stream. Reduced streamflows may likewise reduce the amount of escape-cover and refuge habitats resulting in an increase in fish predation by birds, mammals, and other fish species. Further, streamflow reductions have a downstream effect both in terms of reducing the amounts of habitat (due to low flows) and altering water quality, most notably water temperatures (decreasing the volume of water in a stream allows for increased warming as flows travel downstream). Thus, the effects of flow reductions can extend for a substantial distance downstream.

As noted in Section V, all of the streams for which claims were made in the Wood River subbasin were designated as spring-dominated and have their origins in one or more springs that essentially mark the beginning of the stream. These streams are of special significance in that their temperature and flow regimes tend to be more stable than runoff dominated streams even during the summer months. This is important since salmonids (i.e., trout and salmon) are coldwater fish species that cannot exist for any length of time when temperatures exceed certain thresholds. In general, depending on species tolerances, temperatures ranging from about 7 to 15°C (44.6 to 59°F) (Reiser and Bjornn 1979) are conducive to the growth, maturation, and general health of salmonid populations. Thus, the streams in the Wood River subbasin are especially important during the summer months in providing coldwater habitats that serve to sustain healthy populations of fish.

Based on OWRD records, 27 points of diversion exist on the Wood River (Claim Reach 668): 21 on Crooked Creek (Claim Reach 669) and 32 on Fort Creek (Claim Reach 670) (http://apps2.wrd.state.or.us/apps/wr/wrinfo/wr_summary_pod.aspx). Figure VI-1 depicts representative diversion points on Crooked Creek and the mainstem Wood River. However, the magnitude of the flow reductions has generally been less pronounced than in other subbasins (e.g., the Williamson River, Sycan River and Sprague River subbasins) and has not resulted in severe or complete dewatering of the streams. This is due in part to the influence of springs within the subbasin and the relatively stable flow conditions that exist even during the summer months. However, this does not mean that the flow reductions have no impact on the streams. Rather, the greatest impact of irrigation diversions may be related to potential changes in water temperature. This is because the extent to which streams become warmer during the summer is in part influenced by the volume and temperature of water flowing in the stream. A reduction in flow due to irrigation withdrawals means the volume of water is less, which can result in elevated water temperatures below the points of diversion. While it is true that without water there is no fish or fish habitat, it is likewise true there will be no fish or fish habitat even if water/flow is provided, if it does not meet certain water quality conditions necessary to provide healthy and productive fish habitat (e.g., contain sufficient dissolved oxygen and be of suitable water temperatures for the target fish species).

Figures VI-1a and VI-1b. Photographs depicting selected diversions within the Wood River subbasin. Figure VI-1a (upper photo, September 2004) depicts a view of diversion structure on upper Crooked Creek at ODFW hatchery. Figure VI-1b (lower photo, August 2004) depicts a view of diversion canal off of the main Wood River.

Figures VI-2a (upper photo) and VI-2b (lower photo). Representative views of mainstem diversion (Hawkins Diversion) located about 5 miles upstream from the mouth on the Wood River. Photos received from (William Tinniswood, ODFW) (December 2007).

127. What would be the effect, if any, of the Physical Habitat Claims on current conditions?

At the most basic level, the Physical Habitat Claims would provide the necessary water to the claim reaches of the Wood River under most circumstances. The streams would become dewatered or flows dramatically reduced only in severe natural events such as periods of extreme drought when groundwater supply might be depleted to the point where spring outflow to the streams is reduced. More generally, in addition, to maintaining water in the channel, given their full effect, the Physical Habitat flow claims would provide and maintain healthy and productive fish habitat within the streams, which would include maintaining the existing coldwater temperatures within each of the claims.

The Physical Habitat Claims would assure that, to the extent natural flows are available, water up to the amounts claimed would remain in the streams and provide important habitat for the target fish species and other species that are present. Maintaining the claimed flows over time will improve channel characteristics, increase fish habitat quality and quantity, create habitat diversity, maintain and/or restore hydrologic and habitat connectivity, and improve the degraded conditions that exist in some of the streams of the Wood River subbasin.

128. You mentioned that some of the streams appeared to be in relatively good condition. Please explain what you mean by that.

One of the streams for which we have made Physical Habitat Claims that appears to be in relatively good physical condition include Fort Creek (Claim 670). By good physical condition, I mean there is little visual evidence of any direct man-made influences affecting either the quality or quantity of physical habitats in the stream. The physical characteristics and structure of both the instream habitat and adjoining riparian areas appeared to be largely intact. The reason this stream is in relatively good condition is because it partially is located within lands protected by the State of Oregon or the federal government and are not subject to significant depletions or significant landuse activities that are detrimental to fish habitat.

129. What is the importance, if any, of the streams you characterized as being in "relatively good physical condition?"

For streams in the Upper Klamath Basin, we have uniformly applied a recognized instream flow methodology to provide a healthy and productive fish habitat in all streams singularly and collectively. The Physical Habitat Claims were developed to provide no more water than necessary to provide healthy and productive fish habitat. Providing flows that will continue to promote healthy and productive fish habitats in streams that appear to be in relatively good physical condition is every bit as important as providing flows that will help improve or rebuild the health and productivity of degraded habitats.

Under the Physical Habitat Claims, systems currently functioning properly within an ecosystem context should be protected, while those that are not functioning properly should be improved, or rebuilt/recovered. The utility of the Physical Habitat Claims and the Riparian Habitat Claims clearly fits within this dual, protection-recovery strategy.

130. You have generally described the current conditions of the habitat in the Wood River subbasin, can you now describe the condition of the fish populations. Specifically, are the fish populations of the target fish species that exist within the Wood River subbasin currently healthy, viable, and self-renewing at levels sufficient to support a harvestable fishery?

The answer to that question varies depending on which target species is considered as well as which stream is considered. More importantly, the determination of whether a particular fish population is healthy and capable of supporting harvest is not a simple process and requires a substantial amount of information.

Both Lost River sucker, shortnose sucker, and bull trout currently utilize the Wood River subbasin and are listed under the federal Endangered Species Act (USFWS 2007a) and (USFWS 2007b). This listing indicates that the populations of those target species that exist within streams of the Wood River subbasin are not currently healthy, viable and self-renewing at levels sufficient to support any harvest. The recent decisions of the USFWS based on a 5-year review of the suckers to keep both the shortnose sucker (status: endangered) (USFWS 2007b) and Lost River sucker (status: threatened) protected under the ESA affirms the tenuous conditions of the populations (USFWS 2007a). Similarly, Chinook salmon were extirpated from the Upper Klamath Basin. Upon reintroduction of anadromous fish, successful establishment of returning salmon populations will require substantial effort and time. Until such establishment, the Klamath Tribes cannot look to salmon for harvest.

The Klamath largescale sucker is not listed under the ESA indicating that populations of this species are in better condition than the other two sucker species. However, Moyle (2002) noted that the Klamath largescale sucker is one of the least understood fish in the Klamath River watershed. Moreover, since there have been no quantitative assessments made of the population size of this species, it is not possible to state with any certainty the overall condition of the population, nor whether and to what extent it is capable of supporting any kind of harvest. With waters of the Upper Klamath Basin closed to all fishing for suckers and mullet (see question 147, below), harvest of Klamath largescale suckers is not currently possible.

Finally, as previously described, redband trout exist throughout the Wood River subbasin following either an adfluvial (lake to small stream), fluvial (large stream to small stream), or resident (small stream) life cycle (see Figure IV-5). However, the redband trout populations in the Wood River subbasin are currently managed as a highly regulated sport fishery, with specific regulations/restrictions varying depending on location in the watershed.

131. Please briefly explain what you mean by "harvest."

In essence, harvest represents the biomass of fish that can be removed from a population without having negative impacts on the population's continuance. For a population to be sustainable, a certain number of adult fish are needed to produce sufficient progeny that will survive and grow to maintain or replace the same number of adults; however, if just enough progeny are produced to do this, while the population would be sustainable, it would neither grow nor would there be any surplus fish that could be harvested. On the other hand, if the population of adults is able to produce more progeny than are necessary to maintain the existing adult population, then either the population will increase or the surplus fish can be harvested. Harvest can occur for subsistence, for sport, and for commercial purposes.

132. Please explain what is meant by sport fish harvest.

Sport fish harvest refers to the capture and taking of fish that is done for sport. One important aspect of sport fish harvest is that such harvest is not sold or otherwise traded for profit or money; i.e., the harvest is for sport and not as part of a commercial fishery. Sport fishing is best exemplified by the angling/fishing that is done by the general public for recreational purposes. For some, the attraction to fishing is simply the act of catching a fish and returning the fish to the water unharmed (known as "catch and release" fishing). For others, part of the fun of fishing is being able to eat some of what is caught, which is why ODFW carefully considers creel limits or fish possession limits as part of their regulations.

133. Please describe what is meant by a commercial fishery.

A commercial fishery is one in which fish are harvested for purposes of being sold, bartered, or traded. Commercial fisheries generally operate where fish populations are abundant, traditionally in the open ocean, on certain large rivers, and on some of the Great Lakes. Certain fish species, such as Pacific salmon, are designated as a commercial species since they can be, when their population levels are sufficient, commercially harvested in the ocean.

134. Please explain what is meant by subsistence fish harvest.

Subsistence fish harvest pertains to the capture and consumption of certain fish species for personal, family, and community consumption and subsistence and for traditional/ceremonial purposes. In Oregon, subsistence fishing is generally limited to members of Indian tribes who possess certain treaty rights to fish, hunt and gather. In the case of the Klamath Tribes, the Tribes have a right to hunt, gather, and fish within the former Klamath Reservation. The Klamath Tribes have a long history of using and depending on the native fish species of the Upper Klamath River Basin including the Wood River subbasin, and many accounts exist documenting their subsistence practices. See 281-US-411 and http://www.klamathtribes.org/information/background/cwaam.html.

135. In general, how can you tell whether a particular fish population can allow harvest?

Determining whether a particular fish population is harvestable requires an assessment of whether the population is healthy, viable, and self-renewing. The best way to make this determination is to collect data of the population of fish under consideration over a period of time that allows for an assessment of population metrics that are indicators of the health and viability of the population. This requires the completion of field surveys specifically designed to provide quantitative estimates of the biomass and numbers of fish within the given segment(s) of stream, the results of which can be extrapolated to other stream segments of similar size and morphology. Such metrics typically include, but are not limited to, population estimates (i.e., total numbers and weight of fish within a given stream), information on age class structure (which describes how many members of a given age are present in the population), and length and weight information to describe the growth rates and the general size of members of the population. Collected over time, these types of information can be used to track population trends (in terms of both numbers and biomass) and to identify population vital statistics such as mortality and survival rates. Collectively, this information would allow for an estimate of current population levels relative to potential numbers (if vital rates were changed) and whether and the extent to which harvest could occur.

136. Are there other types of data that can be collected that would not require as detailed of a study?

Yes. Some information on population health can also be gathered with less rigorous surveys designed to evaluate the relative abundance of the fish population based on metrics that typically involve a per unit of area or time basis. Fish sampling (such as electrofishing, seining, trapping, and snorkeling) is conducted within a stream and numbers of fish captured are expressed as fish per area sampled, or fish per unit of effort (e.g., number of fish collected within a certain amount of time, number per seine haul or net set, etc.). These all represent indices of abundance that can be used in combination with other data available, noted above, to evaluate the health and viability of the population.

137. What if you cannot directly sample the fish?

If fish sampling is not available, other metrics and methods exist that could be used to provide some understanding of population health; however, with less data available, an estimate becomes more general and approximate. For example, one method that is often used to indirectly monitor fish abundance over time is to count the number of redds (egg nests) of trout or salmon within a stream. Repetitive counts made over the entire period of spawning will provide an estimate of total numbers of redds for a given year. Assuming that each redd is representative of *at least* two fish (one female and one male, although in many cases more than one male spawns with a female), redd counts can be expanded into approximate estimates of numbers of mature adult fish in the population. Conducted over a period of years, redd counts provide one index of the relative size of the population and its stability; i.e., is the population constant, increasing, or decreasing.

Another method of indirectly monitoring the health of the fishery is *via* a creel census or angler survey. These essentially entail a series of interviews (conducted at specified times and over set periods) with anglers to find out the numbers and sizes of fish captured within a given stream or waterbody. Provided the surveys are conducted in a uniform manner and that anglers are accurate in their responses, annual creel censuses can provide information that is useful for evaluating general trends in population abundance. For example, changes in annual capture statistics (i.e., decreased or increased capture) might suggest changes in population abundance, assuming the same fishing regulations have been in effect over the period of comparison.

138. Are there any abundance or population data of the types you just mentioned available for the target fish species in the Upper Klamath Basin?

Some fish population data are available. A number of entities, including most notably the Oregon Department of Fish and Wildlife, The Nature Conservancy (TNC), the Klamath Tribes, and the USFS have completed fish surveys focused on evaluating fish populations and their habitats within selected streams in the Upper Klamath Basin.

139. What kinds of studies has the Oregon Department of Fish and Wildlife (ODFW) conducted regarding fish populations in the Upper Klamath Basin?

As the primary manager of the fish resources in the Upper Klamath Basin, the ODFW has a long history of completing studies and surveys in the basin designed to monitor the status and health of the fish populations. Based on my review of relatively recent ODFW monthly reports extending from 1990 to 2008, as well as technical documents, the types of studies have ranged from several long term monitoring programs such as redd surveys on Fort Creek (Claim Reach 670) and Crooked Creek (Claim Reach 669) to stream specific studies such as those in support of the TNC on the Wood River subbasin. ODFW has also been involved in radiotagging studies of redband trout designed to track fish movements and behaviors in the Upper Klamath Basin (including the Wood River subbasin) and has been actively involved in efforts to monitor and recover federal ESA listed species in the Upper Klamath Basin.

Finally, in 2005 ODFW completed a statewide assessment of the status of native fish populations (ODFW 2005a) in accordance with the Native Fish Conservation Policy (NFCP) (OAR 635-007-0507).

140. Were streams within the Wood River subbasin included in the 2005 ODFW status assessment?

Yes. One of the ten redband trout populations identified in the Upper Klamath Basin was found in the Wood River subbasin. Members of this population included redband trout from Crooked Creek (Claim Reach 669), Fort Creek (Claim Reach 670), Annie Creek, Sun Creek, as well as the mainstem Wood River (Claim Reach 668).

141. What was the result of the 2005 ODFW status assessment for the redband populations in the Wood River subbasin?

The results indicated that the population of redband trout in the Wood River subbasin passed all six of the criteria, suggesting it is in relatively good condition compared to other populations in the Upper Klamath Basin.

For bull trout, Sun Creek, which is a tributary to Annie Creek passed five of the six criteria. Sun Creek failed in the distribution criterion given its general isolation from other bull trout populations.

142. Do you know how ODFW has used its redband status assessment information?

I can reasonably conclude that ODFW used the assessment as one of several pieces of information to set its fishing regulations post-2005.

143. What generally are ODFW's fishing regulations?

Every year ODFW issues a set of sport fishing regulations as a means to regulate the number and size of fish that can be taken (harvested) by an individual (non-commercial) angler within a given stream or water body. Sometimes the regulations are broad and pertain to an entire watershed, while in some instances there may be very specific regulations for a certain species and for a given stream or stream reach. In the broadest sense, the intent of these regulations is to protect fish populations and keep their numbers at levels that will maintain population viability and sustainability. Thus, regulations will tend to be more restrictive for streams and waterbodies in which the numbers of fish in a population either already are at or could be at levels which could affect the sustainability of the population. Such restrictions might come in the form of restricting the timing and duration of fishing, reducing the numbers of fish that can be captured by an individual angler (called the "creel or bag limit"), changing the minimum size of fish that can be harvested, specifying the use of certain types of fishing gear, and, in some cases imposing "catch and release" restrictions that requires all fish of a given species to be safely released without any harvest.

Each type of restriction can benefit a species in different ways. By restricting the timing and duration of a fishing period, the regulations restrict harvest to periods that minimize impacts on critical lifestages (i.e., spawning). By restricting the number of fish that can be taken, the regulations prevent the fish population from being overfished and overharvested by angling activities. By restricting the size of the fish that can be taken, the regulations serve to protect certain age classes of fish from overharvest, such as large, adult fish that provide substantial reproductive capacity to the population. And finally, by restricting the manner in which fish are caught, the regulations make it more difficult for an angler to catch a fish and, likewise, prevent serious injury to fish that are caught (e.g., fishing restricted to use of artificial lures with barbless hooks). At the extreme end when fish populations are low or have been listed as threatened or endangered, the regulations may simply impose the closure of a stream or waterbody to any fishing for a given species.

144. Do you know how Oregon's fishing regulations are set?

Generally, yes. The annual regulations are set by the Oregon Department of Fish and Wildlife Commission, and that changes to fishing regulations are based primarily on two considerations: conservation of the species and societal values. (William Tinniswood, pers. comm). The Conservation generally pertains to the general health of a given species and considerations relative to ODFW's species protection. The information provided in ODFW's 2005 status review, as well as biological data collected from annual surveys, represent the types of data that would be used in assessing the conservation of the species. Also included in this assessment are aspects related to ESA listed species (e.g., bull trout, Lost River sucker and shortnose sucker); for ESA listed species, conservation takes precedence over all other considerations. With respect to societal values, ODFW considers input and recommendations from local residents, as well as tribes, and local fishing groups regarding fishing regulations. For the Upper Klamath Basin, there has been a general trend over time of the societal recommendations becoming more conservative relative to the regulations; i.e., supporting more restrictive regulations. This is likely due in part to a greater public awareness that in order to preserve and protect fish populations, regulations need to be more stringent.

145. Are you familiar with some of the earlier regulations that were in effect for streams on the Upper Klamath Basin?

Yes. I compiled and reviewed various sets of fishing regulations for the Upper Klamath Basin as a means to determine over time whether and the extent to which the regulations may have changed. My purpose in doing this was to determine whether the regulations had become more restrictive or more lenient, which would be one indicator of the general health of the population, as perceived by ODFW, for that year.

146. How many years of regulations did you compile and review?

My review focused on six years that encompassed a 30-year period that extended from 1979 to 2009; the six years included 1979, 1981, 1992, 1999, 2000, and 2009. These years included periods both before and after ESA listing of the two sucker species (in 1988) and bull trout (in 1999). The comparison focused on the regulations pertaining to five of the target fish species: bull trout, redband trout, and the three sucker species. I focused on the regulations for the Upper Klamath Basin and, to the extent possible, assigned them to individual claim reaches.

147. In general, what did the results of your review of ODFW regulations show?

My review of the regulations showed that over time, the fishing regulations for the majority of streams in the Upper Klamath Basin, including the Wood River subbasin, have become more restrictive. For example, the regulations for the Wood River in 1979 were 10 trout ≥ 6 in./day, with not more than 5 ≥ 12 in. and not more than 2 ≥ 20 in. Possession limits were set at 20 fish or in 7 consecutive days not more than 10 ≥ 12 in., and 4 ≥ 20 in. By 1981, this changed to 5 trout ≥ 6 in./day, with not more than 2 ≥ 12 in. and possession set at 10 fish or in 7 consecutive days not more than 4 ≥ 20 in. By 1992, the regulations became more limiting and specified 1 trout per day with no minimum size limit and 2 daily limits in possession. A further restriction specified that between 4/25-7/31 bait could be used, but with barbless hooks only. From 8/1-10/31 all fishing was catch and release with barbless hooks and lures. Finally, from 1999 to 2009 the Wood River regulations for angling for redband trout are exclusively catch and release, with artificial flies and lures only.

With respect to the sucker species, the 1979 and 1980 regulations were generally silent on specific limits for suckers, and, therefore, the same general bag limits specified for trout applied to suckers. However, the regulations since 1992 all clearly state that all waters containing these sucker and mullet species were closed to angling for these species. This drastic regulation change was made in response to the 1988 decision to list the Lost River sucker and shortnose sucker as protected under the federal Endangered Species Act. This also means that no angling can occur for Klamath largescale sucker that reside in those same waters, a necessary restriction to avoid possible hooking injury or mortality to the listed species.

Likewise, the regulations for bull trout have become more restrictive, and from 1992 to present all waters of the Upper Klamath Basin have been closed to any angling for bull trout. Bull trout were listed as threatened under the federal Endangered Species Act in 1999.

148. What, if anything, does this trend in ODFW fishing regulations tell you regarding the health and viability of the target fish species in the Wood River subbasin?

The trend of increased restrictiveness in ODFW's fishing regulations indicates, in part, the increasing risks to many of the target fish populations. Because of the ESA listing of the shortnose sucker and the Lost River sucker, all angling for sucker species has been eliminated. The restrictions imposed for the sucker species, which do not allow for any harvest, indicates that those populations are not healthy and viable, and are certainly not at levels capable of supporting any harvest.

For redband trout, the trend of increased restrictiveness of the regulations likely reflects a combination of ODFW's conservation directive based on biological data, and an increased societal awareness of the need to protect important fish populations. This is evidenced by the fact that the current regulations specify catch and release only. These restrictions are designed to control the amount of harvest on the populations and protect them from overfishing, which can lead to population declines.

149. Are any of the populations of the target fish species at levels that would allow for a commercial fishery to operate?

No. All of the populations of the target fish species are well below levels that would support commercial harvest.

150. Are any of the populations of the target fish species at levels that would allow for a subsistence fishery to operate?

For the three listed species (i.e. Lost River sucker, shortnose sucker and bull trout), no, the populations are below levels that could even support a subsistence fishery. However, certain populations of redband trout and possibly Klamath largescale sucker might be able to support some incidental, infrequent subsistence harvest, although the numbers of fish taken should be monitored.

151. What is the implication of ODFW's trend in fishing regulations, if any, relative to flow conditions and the Physical Habitat Claims?

In a broad sense, because ODFW fishing regulations currently allow some amount of sport harvest of redband trout in many streams within the Wood River subbasin, it can be surmised that flows within this subbasin have generally supported fish production. However, the ODFW observed in the 2005 native fish status report (ODFW 2005a) that Oregon Basin redband trout populations tend to fluctuate annually with drought cycles and instream flow conditions. Further, Smith and Tinniswood (September 2004) (Ex. 281-US-408) cited some of the fish monitoring results of C. Bienz of The Nature Conservancy (TNC) noting that fish population numbers tended to follow high and low flow water years. For example, results of fish surveys indicated that redband trout abundance in portions of the upper Williamson River was relatively high during the "good" water years of 1997 and 1998, while for one of the sites, no redband trout were captured during the low water years of 1999 and 2000. Although the relationship of flow to habitat to fish populations is generally not direct, if the amount of water remaining in the stream to support fish populations is not protected and tends to decrease with time, as may occur in streams within the Wood River subbasin, then depending on the severity of the flow decreases, I would expect fish populations to decline.

152. How does this relate to the Physical Habitat Claims for the Wood River subbasin?

Fundamentally, the Physical Habitat Claims would reduce the severity of current and potential future flow reductions in streams that would otherwise occur, thereby protecting populations of target fish species. The Physical Habitat Claims would provide flows specifically designed to provide for or maintain healthy and productive habitats in streams currently supporting, or that will support in the future (i.e., Chinook salmon), populations of the target fish species. Coupled with the Riparian Habitat flows that, in part, mimic portions of the high flow hydrograph, the flows will provide a healthy and productive fish habitat in streams that appear to be in relatively good physical condition, and improve or rebuild the health and productivity of currently-degraded habitats.

VII. APPROACH, METHODOLOGIES, AND PROCESS APPLIED TO DEVELOP AND SUPPORT PHYSICAL HABITAT CLAIMS

153. Please summarize the IFIM/PHABSIM method.

Section VII describes a variety of methodologies that exist and are available for developing instream flow recommendations. IFIM/PHABSIM's primary function is to describe a relationship between streamflow and physical habitat by combining information and data pertaining to the physical and hydraulic characteristics of a stream with information that describes the habitat preferences of different fish species and life stages. In general, IFIM/PHABSIM is exercised in three major steps: (i) simulate water surface elevations under different flows; (ii) simulate flow velocities and depths; and (iii) simulate the physical habitat versus streamflow relationships. The first step results in development of what is termed a stage – discharge relationship, which simply means that for a specific location, a given water surface elevation (i.e., stage) corresponds to a specific amount of flow. Hydraulic simulations are used to describe the areas of a stream having various combinations of depth, velocity, and substrate as a function of flow. This hydraulic information is combined with another computer program that incorporates habitat suitability criteria and together this collective information is used to calculate Weighted Usable Area ("WUA"). WUA is a habitat metric that represents an index of the amount of fish habitat present under a given range of flows. The final flows derived are based on the appropriate WUA versus flow relationship for a specific target fish species and lifestage.

As described in Section IV, we selected IFIM/PHABSIM because 1) it is the most widely recognized method in North America, 2) it is recommended by the State of Oregon for use in instream flow studies, and 3) it is the most appropriate method for evaluating incremental changes in habitat with changes in flow. I have used IFIM/PHABSIM repeatedly over my career as a fish biologist whenever there are competing interests for flow and there is a need to assess how different flows change fish habitat.

154. You mention "weighted usable area (WUA)." Please describe this further.

WUA represents an index of the amount of habitat present in a given stream location under a given range of flows for a certain species and life stage of fish. The stream parameters that are considered in the computation of WUA are water depth, water velocity, and stream-bed substrate. The first two of these are directly related to stream flow (water depth and water velocity), while the latter (substrate), although fixed, does change by stream location.

In the IFIM/PHABSIM process to determine the WUA, the cross-sectional stream profile is divided into numerous individual cells and analyzed for depth and velocity suitability. Respective depths and velocities assigned to a given cell are computed as averages of measured depths and velocities from adjacent vertical measurement points. One way to think about WUA is to view a river or stream as being comprised of small, 3-dimensional cells with each cell representing some combination of depth and velocity. Figure VII-1 illustrates a cross-sectional view of a river that contains many 3-dimensional cells that collectively would be analyzed to determine WUA.

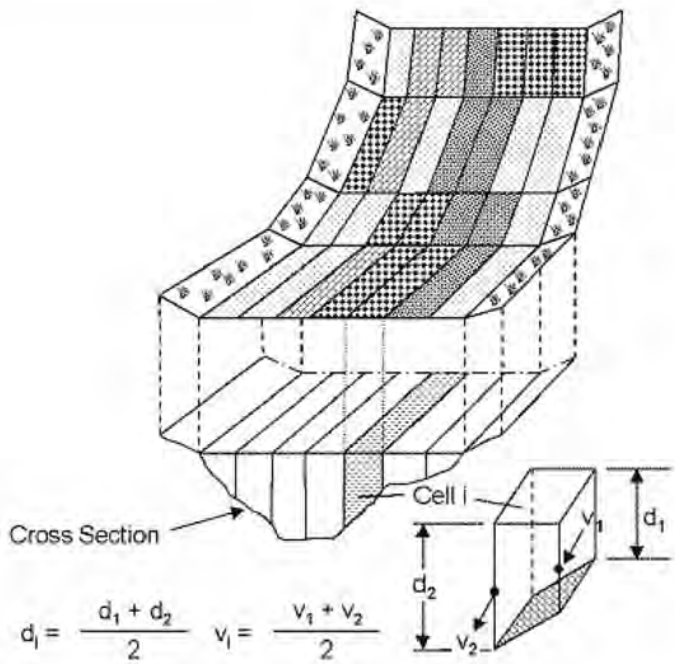


Figure VII-1. The cross-sectional stream profile is divided into numerous individual cells and analyzed for depth, velocity, and substrate suitability.

As streamflow increases or decreases, the values of depth and velocity within each parcel also change. Since each of the depth and velocity combinations in a parcel represents a certain amount of habitat, then by extension, as flows change, the amount of fish habitat changes. The "weighting" of the habitat comes into play by factoring in the relative value of each depth, velocity, and substrate combination as defined by the preference for that combination by different fish species and their life stages. This "weighting" is illustrated in Figure VII-2, which depicts the computational process of WUA that occurs via linking of the measured depths, velocities, and substrates defined for a given parcel with respective Habitat Suitability Curve (HSC) criteria for different species and life stages. If life stage and species preferences for various depth and velocity combinations can be determined over the entire range of parcels that occur in a stream, then the actual amounts of habitat that are contained within each parcel will be weighted and combined accordingly. Thus, the summation of the weighted habitat areas represents the weighted useable area (WUA) for a given flow of that species and life stage.

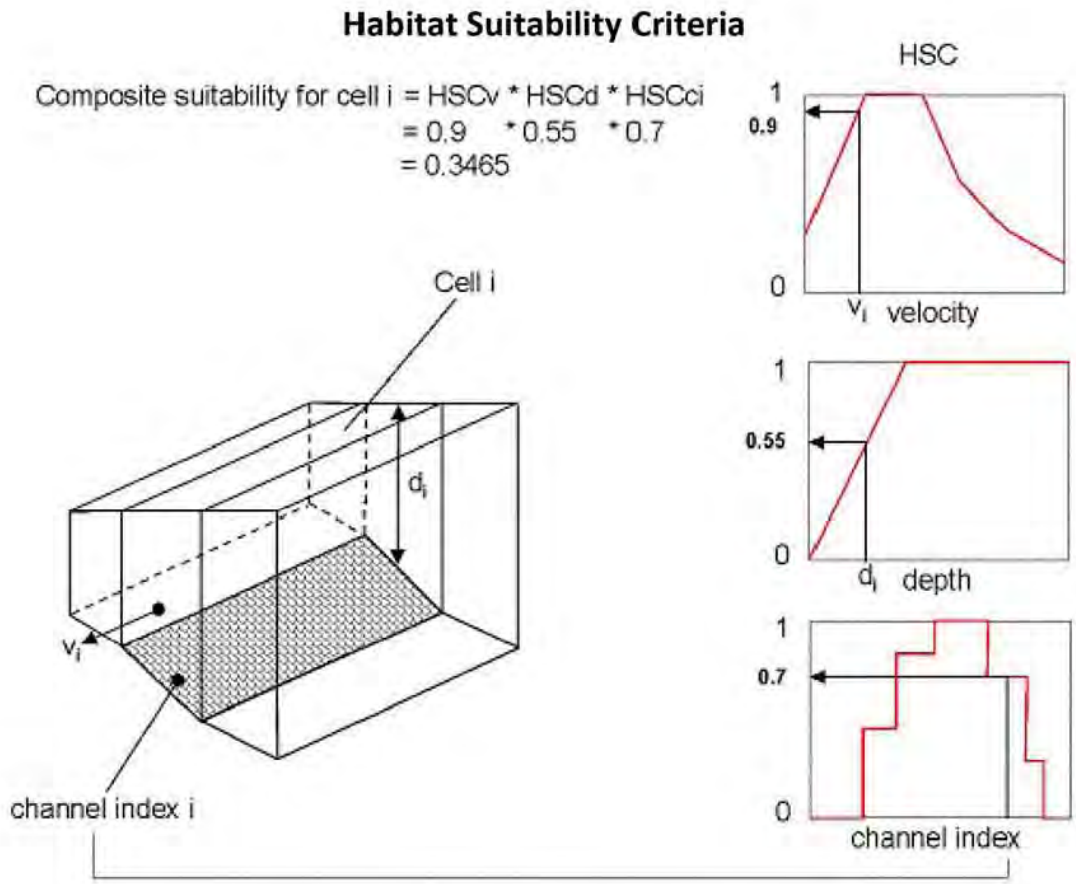


Figure VII-2. Illustration of a representative water cell within a stream. The cross-sectional stream profile is divided into numerous individual cells (see Figure VII-1) and analyzed for depth and velocity suitability, and the suitability of the stream substrate (designated here as channel index). The figures on the right depict representative Habitat Suitability Curve (HSC) criteria which are used in the computation of WUA for a given cell, represented here for Cell i.

It is important to recognize that the WUA of a stream reach changes with flow; however, maximum flows do not simply result in greater amounts of WUA or fish habitat. This is because as flows increase, water velocities will likewise increase and will ultimately exceed those preferred by a given species or life stage. At that point, increases in flow will actually begin to decrease the amount of WUA. An illustration of four overlaid redband trout WUA curves is provided below in Figure VII-3.

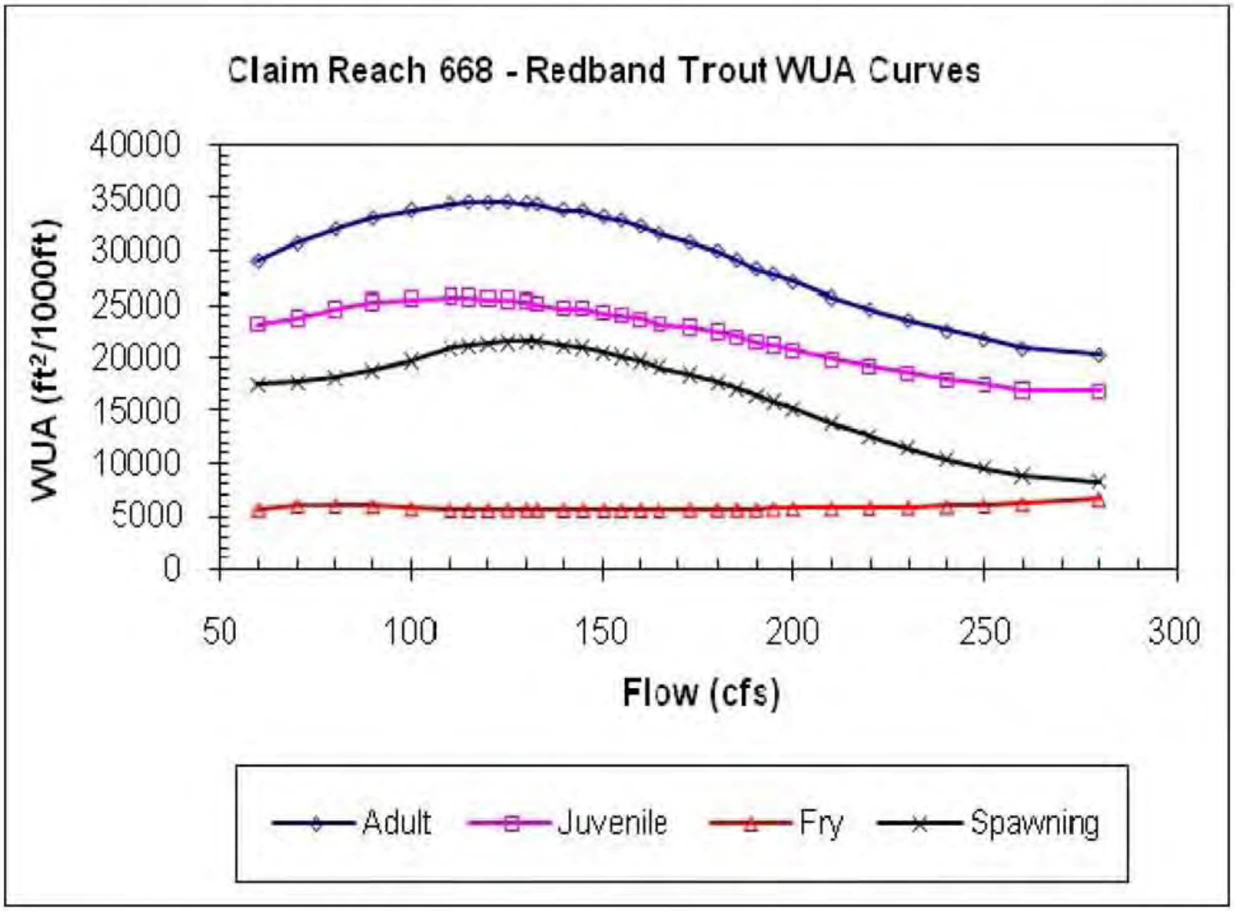


Figure VII-3. Example WUA:flow curves for the four life stages of redband trout for Claim Reach 668. Different habitat:flow relationships exist for each of the four life stages.

155. Please describe the approach that you used to develop the Physical Habitat Claims.

The basic approach used was to apply a nine-step decision framework that ultimately provided the necessary information from which to derive the Physical Habitat Claims. This nine-step framework gathered the data and information collected throughout the two decades of work in the Upper Klamath Basin including data analysis and IFIM/PHABSIM modeling results (or in one instance, results applying the Tennant methodology). Each of the nine steps contributed pieces of information or data that was ultimately considered and or used in the final derivation of the Physical Habitat Claims (described in Section VIII of my Direct Testimony).

156. Have you ever employed this decision framework on any other projects?

I have been involved in more than 50 other instream flow investigations which employed many of the same methods and techniques we applied in this basin.

157. In gathering the data and information necessary to derive the Physical Habitat Claims, how was this work organized?

The gathering of data and information necessary to support the Physical Habitat Claims required an extensive, coordinated effort over many years. Nine steps were taken that led to the development of the Physical Habitat Claims. Each step contributed pieces of information or data that were ultimately used in the final derivation of the Physical Habitat Claims.

158. Please describe the nine steps that led to the development of the updated Physical Habitat Claims that you present in your testimony today.

The nine steps that led to the development of the updated Physical Habitat Claims are:

Step 1 – Identification and Selection of Claim Reaches and Study Sites;
Step 2 – Selection of Target Fish Species;
Step 3 – Determine Species Distribution and Life Stage Periodicity;
Step 4 – Life Stage and Species Prioritization;
Step 5 – Development of Species Habitat Suitability Criteria (HSC) Curves;
Step 6 – Field Data Collection;
Step 7 – Instream Flow Hydraulic and Habitat Modeling;
Step 8 – Hydrologic Limitations – Median Flow Threshold; and
Step 9 – Other Flow Considerations – Limitation of 1999 Amended Flow Claim.

Section VIII describes the final review of the information gathered in a logical, systematic manner to make final updates to the Physical Habitat Claims.

159. Does the order in which the nine steps are presented reflect how they were completed?

The steps do not necessarily reflect a strict temporal sequence in which they occurred. The steps are listed in logical sequence, but the completion of each may have varied temporally.

160. Please describe the first step of the nine-step process – Identification and Selection of Claim Reaches and Study Sample Sites.

Because the drainage area represented by the Wood River subbasin includes a 16-mile reach of the mainstem Wood River and several tributary streams, the first step focused on the identification and selection of specific study reaches within a claim reach and still smaller study sites from which physical and hydraulic data would be collected and which would form the basis for the Physical Habitat Claims. A "claim reach" is that section of the stream to which a tribal Physical Habitat water claim applies. A "study reach" is that portion of the "claim reach" that was surveyed and habitat mapped to determine the composition of habitat types. And finally, a "study site" is the portion of the "study reach" that was randomly selected for detailed study. The "study site" contains the transects that were surveyed and from which field data were collected.

161. How did you complete Step 1?

Initially, we compiled and reviewed USGS topographic maps of the drainages to become familiar with watershed boundaries, topographic features, and the overall network of streams within the Upper Klamath Basin. In consultation with the Klamath Tribes, we identified specific streams and stream reaches that are important to the Tribes' fishing, hunting, trapping, and gathering. A site reconnaissance was completed to assess the physical setting of the subbasins and to view a representative number of streams. Based on this review, a list of candidate streams for study was developed.

162. How was the candidate list of streams used?

We used the candidate list as a means to focus our field-work efforts. First, we located the streams on USGS maps and divided the streams into claim reaches, based on a number of considerations: the size and length of the respective streams; the change in topography or landscape around the stream; tributary junctions with the main stem river; an initial review of the diversity of habitat types present in each system; areas of importance for fish species; and property ownership and access limitations. Once claim reaches were identified, we selected study reaches based on channel characteristics (e.g., channel slope, confinement) we considered representative of those occurring within the claim reach. The study reaches were marked on the USGS maps and subsequently used in the field to guide selection of study sites. Unless field inspection revealed unforeseen circumstances such as access problems, the study sites were randomly selected within the study reaches.

163. What was the final number of study sites that were established in the Wood River subbasin?

Based on the process described above, a total of 3 instream flow study sites were established in the Wood River subbasin. These sites were located on the main-stem Wood River and its two major tributaries, Fort Creek and Crooked Creek. A list of claim reaches is provided in Table VII-1 and displayed in Figure VII-4.

Table VII-1. Wood River Drainage Claim Reach Numbers and Upper and Lower Boundaries

Claim Reach No.	River/Stream	Upper Boundary	Lower Boundary
668	Wood River	Annie Creek	Agency Lake
669	Crooked Creek	Crooked Creek source	Wood River
670	Fort Creek	Reservation Spring	Wood River

164. Are all of these claims located within the boundaries of the Klamath Reservation?

No. The mainstem Wood River claim (Claim 668) encompasses the reach from the mouth of the Wood River as it enters Agency Lake/Upper Klamath Lake[1] upstream to where Annie Creek enters the Wood River. The mainstem Wood River claim (Claim 668) includes a large segment (approximately 14 miles) within the former Reservation boundary, while the upper 2 mile segment (approximately) extends beyond the former Reservation boundary up to the confluence with Annie Creek. The stream reaches encompassed by Claim 669 and Claim 670 are within the former Reservation boundary.

[1] Upper Klamath Lake and Agency Lake are connected and are generally considered to be two parts of the same water body, with Upper Klamath Lake comprising 85 to 90 percent of the total surface area. Agency Lake is the northern most lake and receives direct inflow of the Wood River; the Williamson River flows directly into Upper Klamath Lake. Hereafter, the term "Upper Klamath Lake" includes Agency Lake.

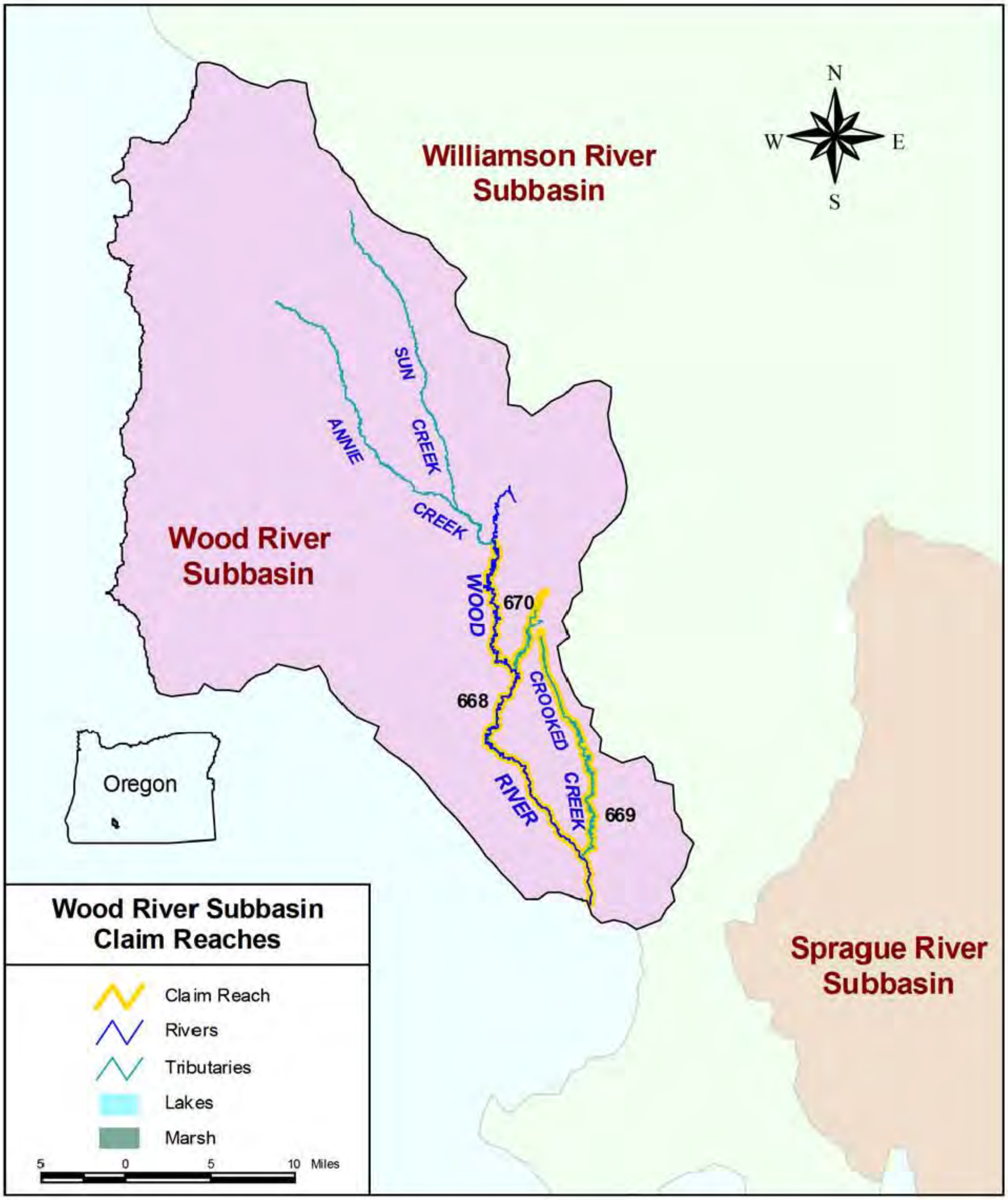


Figure VII-4. Location of Physical Habitat Claims in the Wood River subbasin.

165. Why have these claims been included if they are not within the former Reservation boundary?

As I described in Section IV, unless there are natural (e.g., water falls, log jams) or human created (e.g., dams, diversion structures, dewatered sections of streams) structures or conditions that physically obstruct upstream and/or downstream passage of fish, fish populations will move freely within a stream in response to life cycle needs such as for spawning, foraging for food, or seeking shelter or better water quality conditions. While the distances migrated may be greater for populations that exhibit an adfluvial or fluvial life history strategy (see Section IV), even resident fish populations will freely migrate within a stream. The mere fact that a reservation boundary crosses a stream will not prevent fish from moving above and below that boundary to fulfill specific biological needs. To the fish, there is no reservation boundary, just as there is no Forest Service boundary for fish that reside in streams that extend into properties administered by the U.S. Forest Service. Fish simply do not recognize human imposed boundaries on a map, unless they comprise a physical barrier. The claim reaches were established to protect all of the stream segments and associated habitat components biologically necessary to fulfill the life cycle needs of the target fish species. That some of these segments/habitat components extend beyond the former Reservation boundary does not negate their importance and the need for sufficient flows to provide healthy and productive habitat.

166. Please describe Step 2 of the nine-step process - Selection of Target Fish Species.

Step 2 was conducted in parallel with the selection of claim reaches and study sites. Early on in the project, as discussed in Section II above, we identified fish species of importance termed "target fish species" and listed in Table VII-2. The six species include three salmonid species (Chinook salmon, redband trout, and bull trout) and three catastomid species (shortnose sucker, Lost River sucker, and Klamath largescale sucker); all are native to the Upper Klamath Basin. These native fish species are treaty species which represent species that currently are or historically were harvested by the Klamath Tribes. In addition, these target fish species are those that state (ODFW) and federal (USFWS, NMFS) agencies have found are important. The species selection and prioritization process we used is commonly applied on projects involving decisions related to flow quantification, regulation, and management. For example, I was recently involved on two projects associated with hydroelectric relicensing in which a similar procedure was applied, the first as part of the instream flow studies on the Clackamas River in Oregon, and most recently, an instream flow study for the Sultan River in Washington.

Table VII-2. Common and scientific names of the six target fish species considered for the Upper Klamath Basin and indication of their presence in the Wood River subbasin.

Common Name	Scientific Name	Current and Historical Presence in the Wood River subbasin
Chinook salmon	*Oncorhynchus tshawytscha*	*Currently absent/Historically present*
Redband trout	*Oncorhynchus mykiss newberrii*	*Currently present*
Bull trout	*Salvelinus confluentus*	*Currently absent/Historically present*
Lost River Sucker	*Deltistes luxatus*	*Currently present*
Shortnose Sucker	*Chasmistes brevirostris*	*Currently present*
Klamath Largescale Sucker	*Catostomus snyderi*	*Currently present*

167. Are there other species of fish in the Wood River subbasin besides the six target fish species noted above?

Yes. A number of native and non-native fish species exist in the Wood River subbasin. OWRD Ex. 2 pp. 4 through 5 contains a more detailed listing of fish and aquatic species, both native and non-native, found in the Upper Klamath Basin generally. Although steelhead are not currently present, historical records indicate steelhead were present in the Wood River subbasin (Hamilton et al. 2005). Steelhead were not identified as a target species, but we have concluded that steelhead flow requirements would be satisfied based on those of the redband trout because redband trout and steelhead trout are taxonomically similar (both are *Oncorhynchus mykiss*, and the size and physical characteristics of adfluvial redband closely resemble the size and physical characteristics of steelhead).

168. You stated that the three salmonid target fish species (Chinook salmon, bull trout, and redband trout) are species of importance. Generally what is the importance of these three species?

Chinook salmon is a fish species that was historically present in the Wood River subbasin, however, it is not currently present in the subbasin or anywhere in the larger Upper Klamath Basin. As described in detail in Dr. Hart Direct Testimony at questions 19 through 47 and 54 through 61 and as frequently identified in publications, anadromous fish, including Chinook salmon, were historically present in the subbasin before the construction of impassable dams on the Klamath River at the turn of the 20th Century (Hamilton et al. 2005; Fortune et al. 1966; Logan and Markle 1993).

Recent studies suggest that with the provision of suitable passage facilities at downstream dams or dam removal, Chinook salmon could be re-introduced and restored to waters in the Upper Klamath Basin (Huntington and Dunsmoor 2006; Hooton and Smith 2008). Also, the Federal Energy Regulatory Commission (FERC) recently decided that if a license to operate the dams is reissued it will be conditioned on providing adequate salmon passage around those dams (FERC 2006; Hooton and Smith 2008). The action taken by FERC in conjunction with recognition of the re-introduction feasibility supports the likelihood of salmon returning to the

Upper Klamath Basin in the foreseeable future. Therefore, Chinook salmon is included as a target fish species with the understanding that the Physical Habitat Claims developed for them is conditional upon reintroduction into the Upper Klamath Basin.

Bull trout, another target fish species was likewise historically present within the Wood River drainage (Buchanan et al. 1997), but today is limited to the upper 6.2 miles of Sun Creek, Given that Sun Creek flows into Annie Creek which flows into the Wood River, it is my opinion that bull trout historically used, and will in the future again utilize, segments of the main-stem Wood River that are both within and upstream (i.e., above the former Reservation boundary) of the claimed reaches. However, there are no immediate plans for the reintroduction of bull trout into any of the streams within the Wood River subbasin covered by the claims, and, therefore, bull trout was not part of claim development in the Wood River subbasin.

The other salmonid target fish species is redband trout. This species is perhaps the most ubiquitous salmonid species present in the basin (Smith et al. 2003 (Ex. 281-US-409) and Messmer et al. (2000) (Ex. 281-US-410)). However, it is still unique in that at least two different life history strategies (adfluvial and fluvial) are likely expressed by redband trout populations within the Wood River subbasin. The adfluvial form of redband trout is a large-body fish that live in Upper Klamath Lake and migrate into the Wood River subbasin to spawn. Behnke (1992) suggested that ancestors of these fish may have been anadromous steelhead. The fluvial form of redband is smaller and spends most of its adult life in the mainstem Wood River and then moves into tributaries (e.g., Crooked and Fort Creek) to spawn.

169. Generally, what is the importance of the sucker target species?

The two sucker species currently present in the Wood River subbasin (Lost River sucker and shortnose sucker) are endemic and found only in Upper Klamath Basin. Both species are long-lived, with the Lost River sucker reportedly living as long as 43 years or more, and, the shortnose for as long as 33 years or more (Scoppettone 1988). Both of these species were listed as endangered under the federal Endangered Species Act in 1988. These two species are also of special cultural significance to the Klamath Tribes and were historically a primary food source (see 281-US-411). Indeed, each spring the Tribes hold a ceremony marking the return of these fish (http://www.klamathtribes.org/suckers.htm). With the Lost River sucker and shortnose sucker species threatened with extinction in the Upper Klamath Basin, the Tribes do not currently harvest any sucker species.

170. Are the six target fish species of importance to the Klamath Tribes?

Yes. The standing policy management statement of the Klamath Tribes describes the general importance of the target fish species to the Tribes. See Ex. 281-US-411.

171. Was there anything else noteworthy related to Step 2?

Yes. The current absence but likely future presence of anadromous fish species, and specifically Chinook salmon, within the Wood River subbasin caused a refinement in the process we used in developing the Physical Habitat Claims. Specifically, the updated Physical Habitat Claims are divided into two components: 1) Physical Habitat Claims based on *present* target fish species; and 2) Physical Habitat Claims based on *all* target fish species, which includes Chinook salmon. The former claims are referred to as *present* claims, and the latter are referred to as *conditional* claims, and should only go into effect when anadromous fish are reintroduced into the Upper Klamath Basin.

172. Please describe Step 3 of the nine-step process - Species Distributions and Life Stage Periodicities.

The biological basis and justification for the Physical Habitat Claims centered on determining the flow quantities necessary to provide no more than that flow necessary to provide a healthy and productive habitat for target fish species. Thus, I wanted to make sure that a flow claim for a particular reach was based on the target fish species that actually occurred or would likely occur within the reach. Once the six target fish species were identified, our efforts focused on determining their distribution within the Wood River subbasin. Our efforts also focused on determining the periodicity and distribution for each fish species.

173. Please explain what "periodicity" and "distribution" means.

As mentioned in Section IV, the periodicity of a fish species describes the specific biological functions that are occurring at a given time. In other words, a fish's life can be partitioned into phases or periods, which fish biologists call "life stages." These include the spawning life stage (i.e., reproduction/conception), the incubation/hatching life stage (i.e., birth), the fry life stage (baby), and the juvenile (inclusive of youth to juvenile) and adult life stages. Thus, for example, the periodicity of redband trout involves five life stages (spawning, egg incubation, fry, juvenile, and adult) each occurring at a specific time of the year.

Since Physical Habitat Claims were made for many different segments and tributaries of the Wood River, we needed to know the species distribution (i.e., the target fish species found within each claim reach), and the periodicity of each species, (i.e., the specific life stages occurring in specific geographic areas in each month of the year). In the case of Chinook, we needed to know its potential distribution and periodicity within the basin.

174. Please explain how you determined the distribution of the target fish species within the Wood River subbasin.

Distribution of the species was determined with information gathered through a number of sources: the compilation and review of available published and unpublished information; personal contacts with local fish biologists from the U.S. Forest Service (Dick Ford), U.S. Bureau of Reclamation (Mark Buettner), U.S. Geological Survey (Rip Shiveley), Oregon Department of Fish and Wildlife (Roger Smith and William Tinniswood), and the Klamath Tribes (Craig Bienz and Larry Dunsmoor); and direct observations and technical studies we performed in the subbasin.

175. What do you mean by published and unpublished information?

Published information is information that typically has gone through a peer review process and then is formally published or presented through a number of avenues: scientific journals, books, graduate thesis and dissertations, and peer reviewed proceedings of scientific symposia. Published information relied upon to determine the distribution of target species within the Wood River subbasin included, but was not limited to, Moyle (2002), Wydoski and Whitney (2003), and Nehlsen et al. (1991). Types of unpublished information include technical reports, technical memorandum, data summaries, technical presentation materials, and other information. Unpublished information relied upon to determine the distribution of target fish species within the Wood River subbasin included, but were not limited to, the reports of Buettner and Scoppettone (1990), Bienz and Ziller (1987) (Ex. 281-US-412); and Craven Consulting Group 2004 (Ex. 281-US-413).

176. You stated that you conducted technical studies in the basin for defining the distribution of fish species in the basin. Please describe those studies.

We completed several field sampling efforts to document species occurrence and composition within different sites. These included a 1993 effort that involved electro-fishing 2 sites in the Wood River subbasin (1 site on Fort Creek (Claim 670) and 1 site on Crooked Creek (Claim 669). Additional field surveys were completed in 1998, 2003, 2006, and 2007 within a variety of the claim reaches in the Upper Klamath Basin. These were part of the field efforts focused on collecting site specific habitat utilization which I describe further below. However, they also served to document species presence within the areas surveyed. A listing of fish species we observed in the Wood River subbasin as part of these field efforts as well as species documented from other information sources is found in Table VII-3.

Table VII-3. Fish species found in the Wood River subbasin.

Fish Species	Common Name	References
SALMONIDAE	TROUTS	
Oncorhynchus mykiss newberrii	rainbow trout / redband trout	EA 1994; ODFW 2005a
Oncorhynchus tshawytscha	Chinook salmon*	Hamilton et al. 2005
Salmo trutta	brown trout	EA 1994; Craven Consulting Group 2004 (Ex. 281-US-413)
Salvelinus confluentus	bull trout*	Buchanan et al. 1997; USFWS 2005
Salvelinus fontinalis	brook trout	EA 1994; Craven Consulting Group 2004 (Ex. 281-US-413)
PETROMYZONTIDAE	LAMPREYS	
Lampetra lethophaga	Pit-Klamath brook lamprey	Lorion et al. 2000; Craven Consulting Group 2004 (Ex. 281-US-413)
Lampetra tridentata	Pacific lamprey	EA 1994
COTTIDAE	SCULPINS	
Cottus klamathensis	marbled sculpin	EA 1994
CATOSTOMIDAE	SUCKERS	
Castostomus snyderi	Klamath largescale sucker	Craven Consulting Group 2004 (Ex. 281-US-413)
Chasmistes brevirostris	shortnose sucker	Markle and Simon 1993 (Ex. 281-US-414); USFWS 1994; White et al. 1995; Craven Consulting Group 2004 (Ex. 281-US-413)
Deltistes luxatus	Lost River sucker	Markle and Simon 1993 (Ex. 281-US-414); USFWS 1994; White et al. 1995; Craven Consulting Group 2004 (Ex. 281-US-413)

* historical presence

177. Were you able to establish a distribution of target fish species throughout the Wood River subbasin?

With the information I just described, we went through each of the streams in the Upper Klamath Basin and systematically assigned a presence or absence of each of the target fish species. In the end, we were able to integrate these data into a GIS format and create fish species distribution maps for each of the streams in the Wood River subbasin. These maps and accompanying data were used in assigning the appropriate target fish species to a given claim reach. Figures VII-5a through 5f are the fish distribution maps developed for the Wood River subbasin.

178. Since Chinook salmon are not currently present in the Wood River subbasin, how did you assign its distribution in the basin?

For Chinook, we reviewed the published and unpublished information that described its historical distribution in the Upper Klamath Basin. The reports of Hamilton et al. (2005), Fortune et al. (1966), and Nehlsen et al. (1991), and Dr. Hart Direct Testimony at questions 19 through 47 and 54 through 61 were especially useful. With historical information, we could reasonably evaluate each of the streams of the subbasin to determine whether a specific claim reach would provide Chinook salmon habitat. Figures VII-5f depicts the historic and potential distribution of Chinook salmon within the Wood River subbasin.

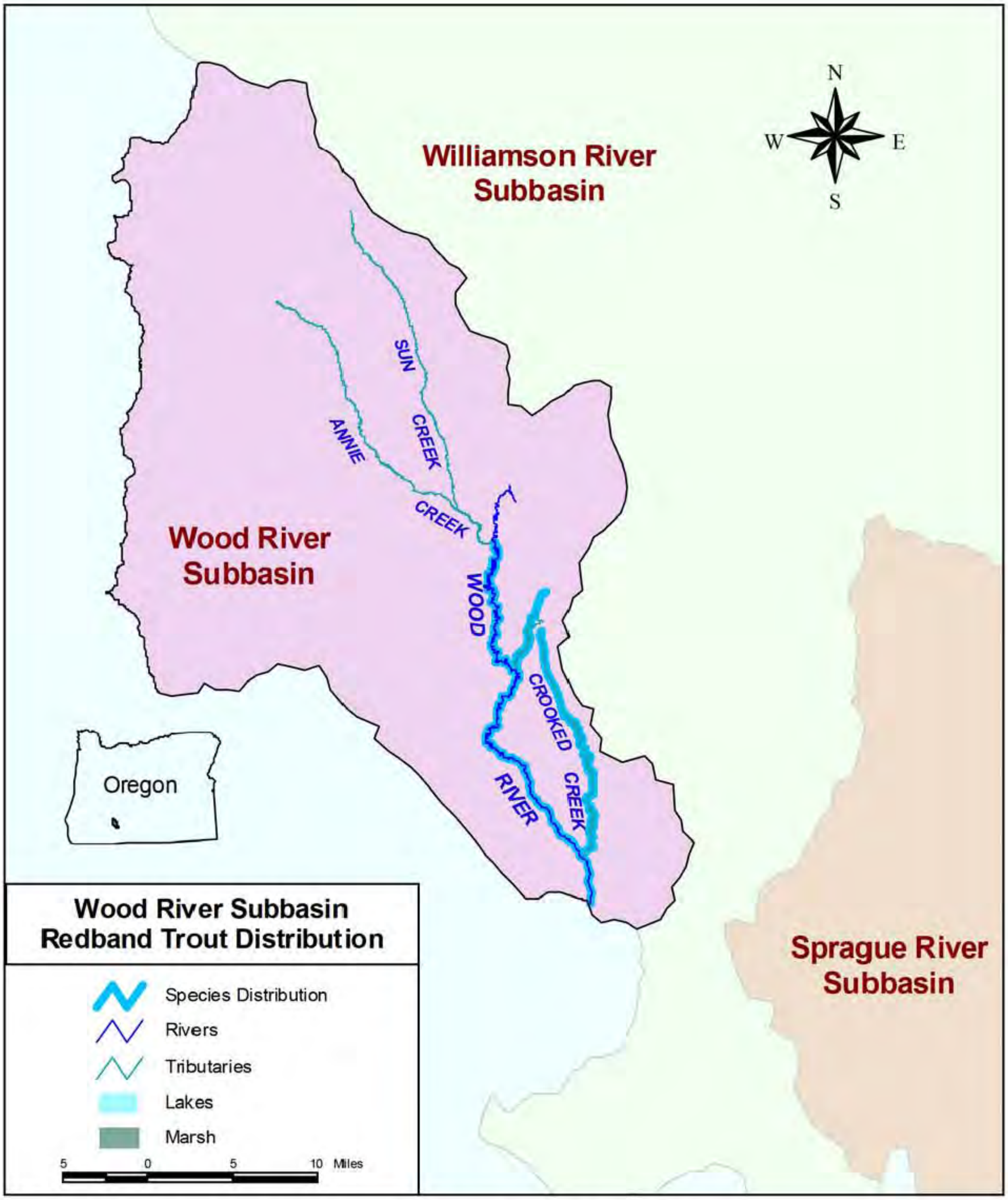


Figure VII-5a. Redband trout distribution in the Wood River subbasin.

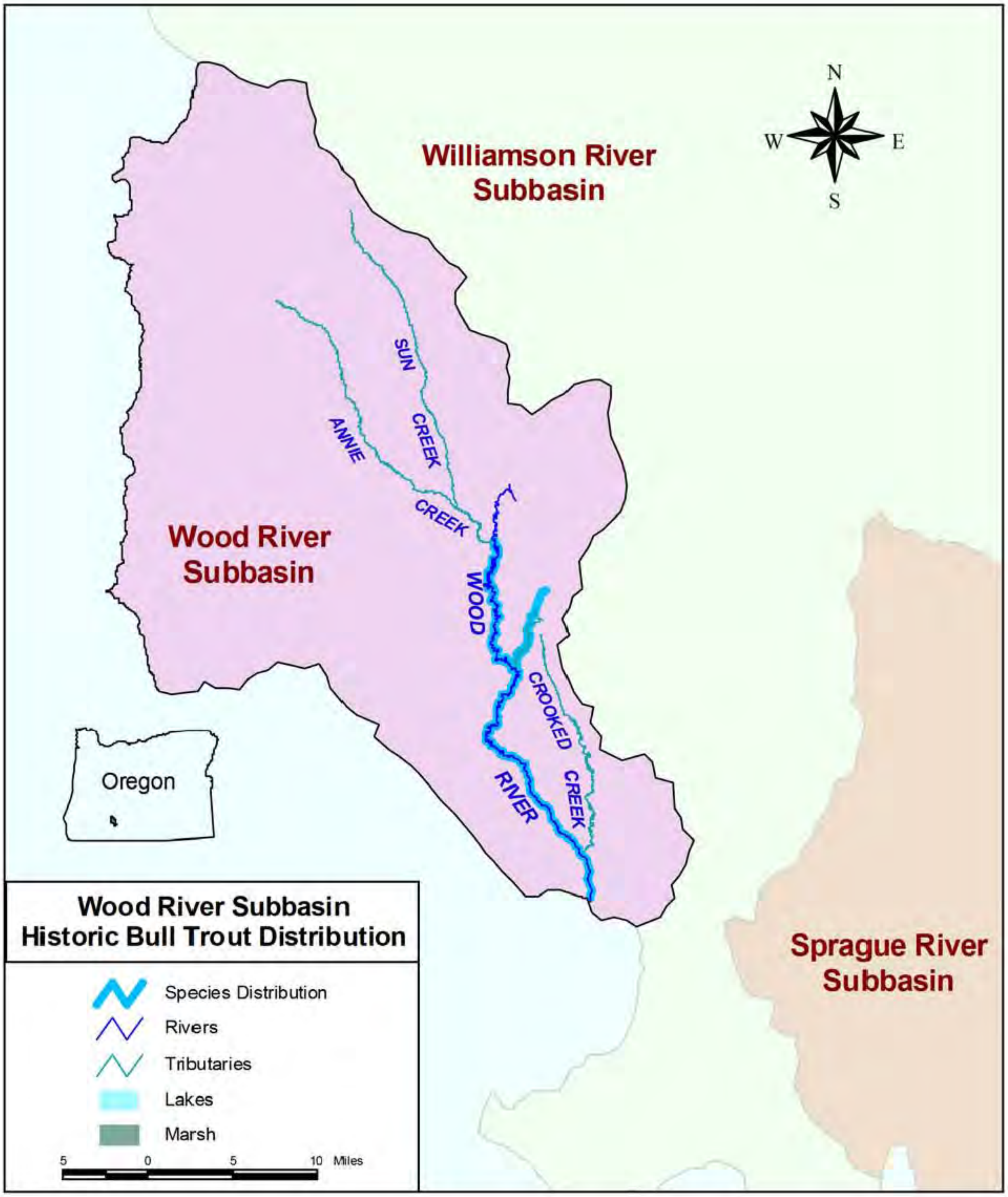


Figure VII-5b. Historic and anticipated bull trout distribution in the Wood River subbasin.

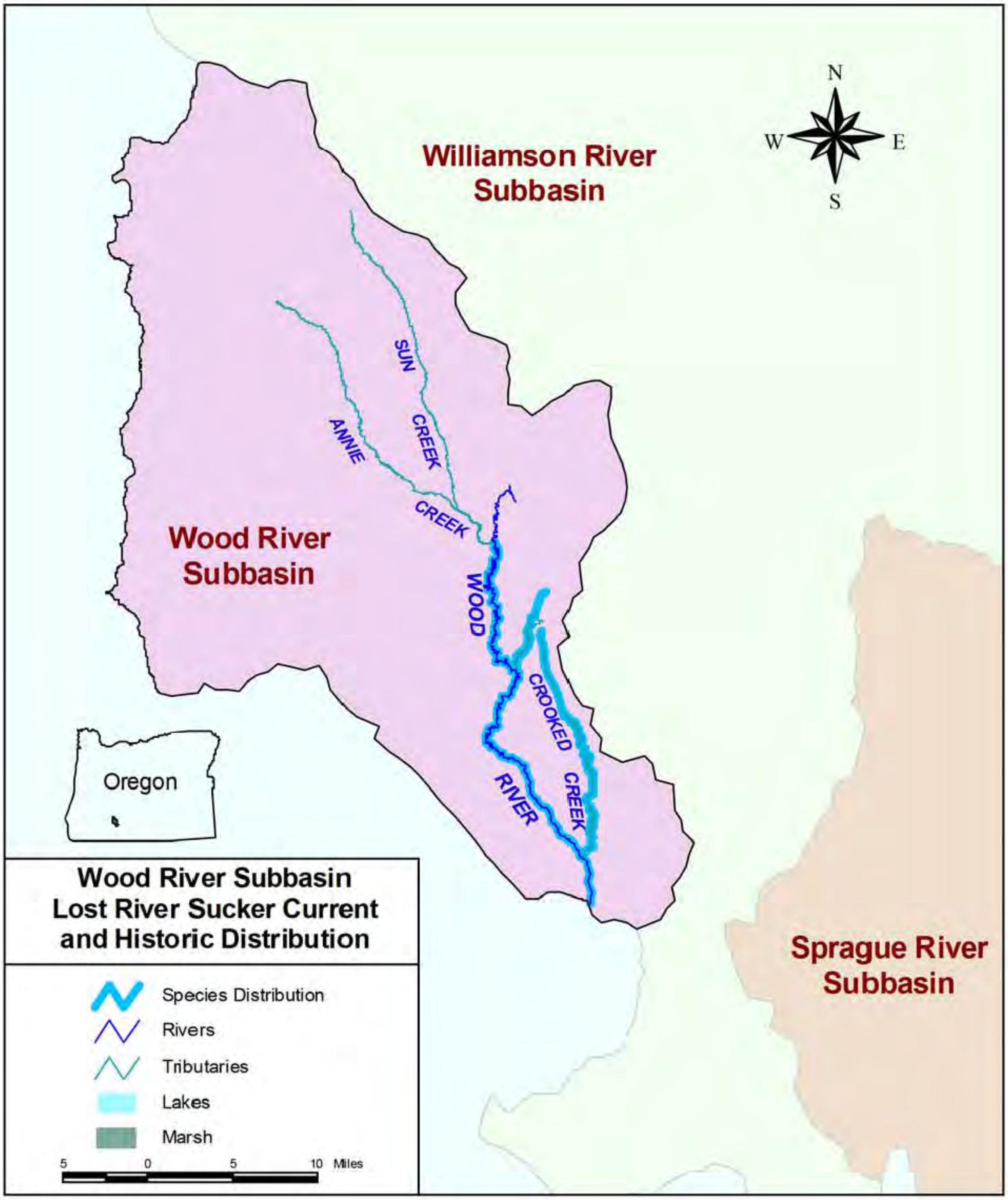


Figure VII-5c. Lost River sucker distribution in the Wood River subbasin.

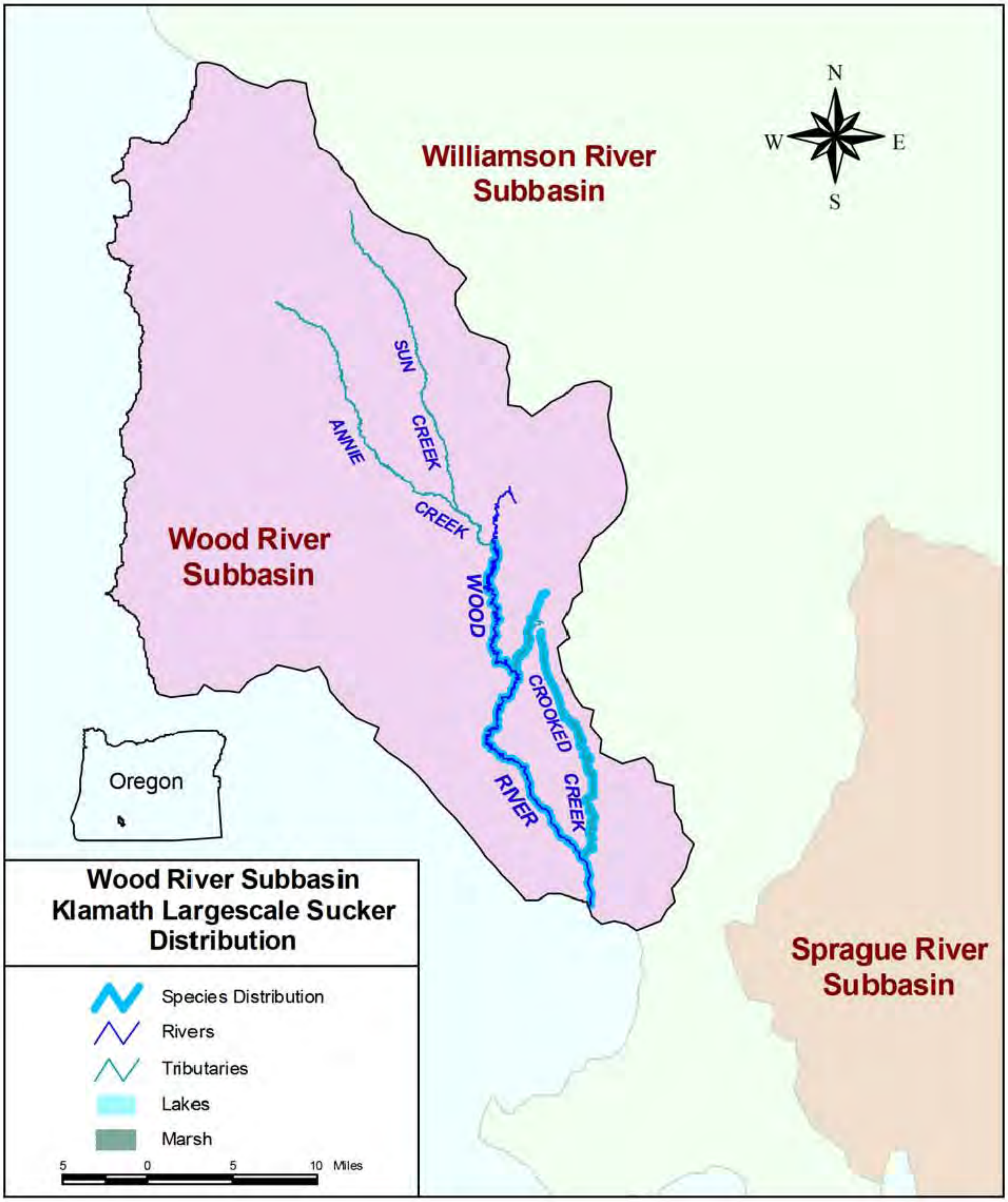


Figure VII-5d. Klamath largescale sucker distribution in the Wood River subbasin.

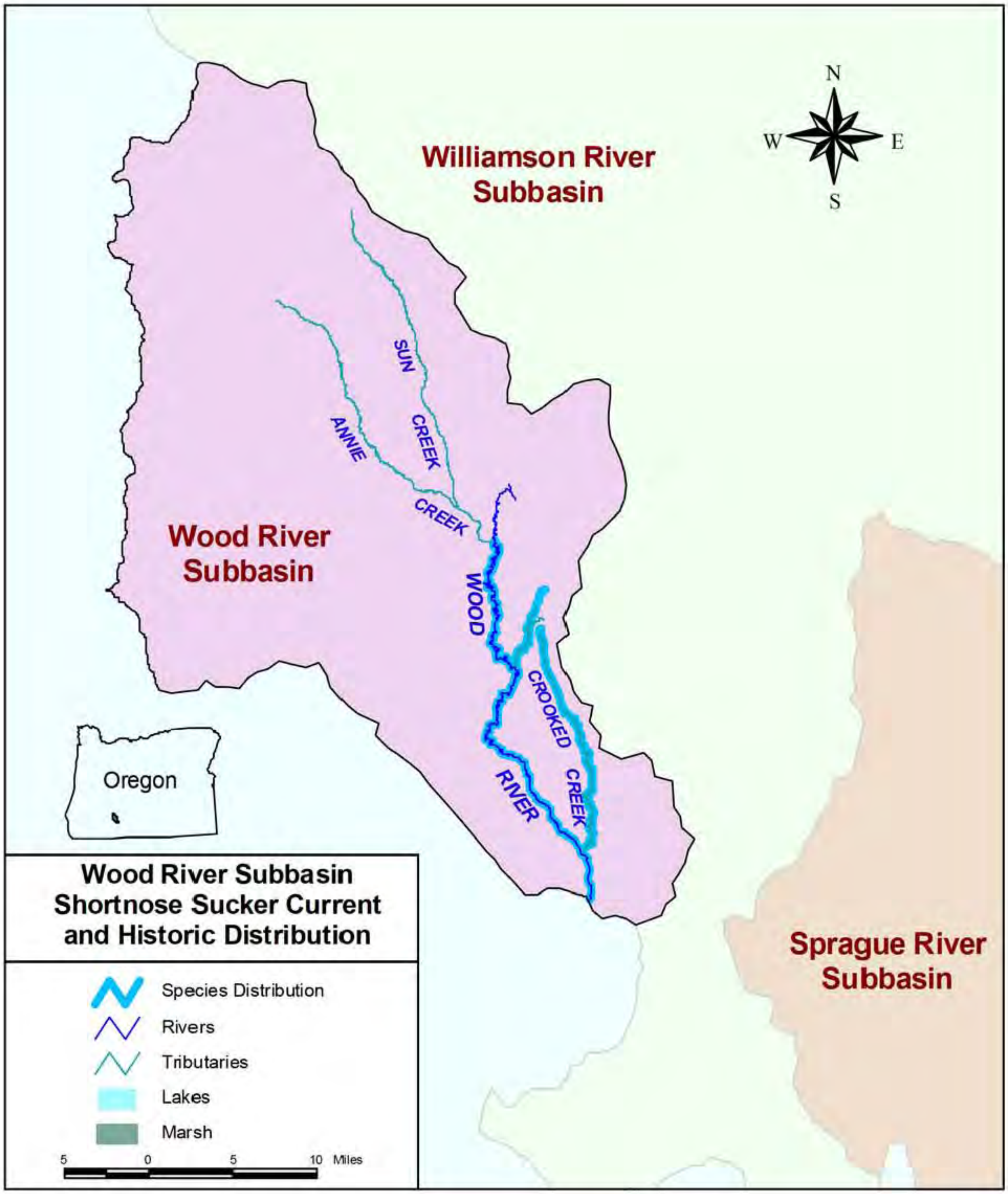


Figure VII-5e. Shortnose sucker distribution in the Wood River subbasin.

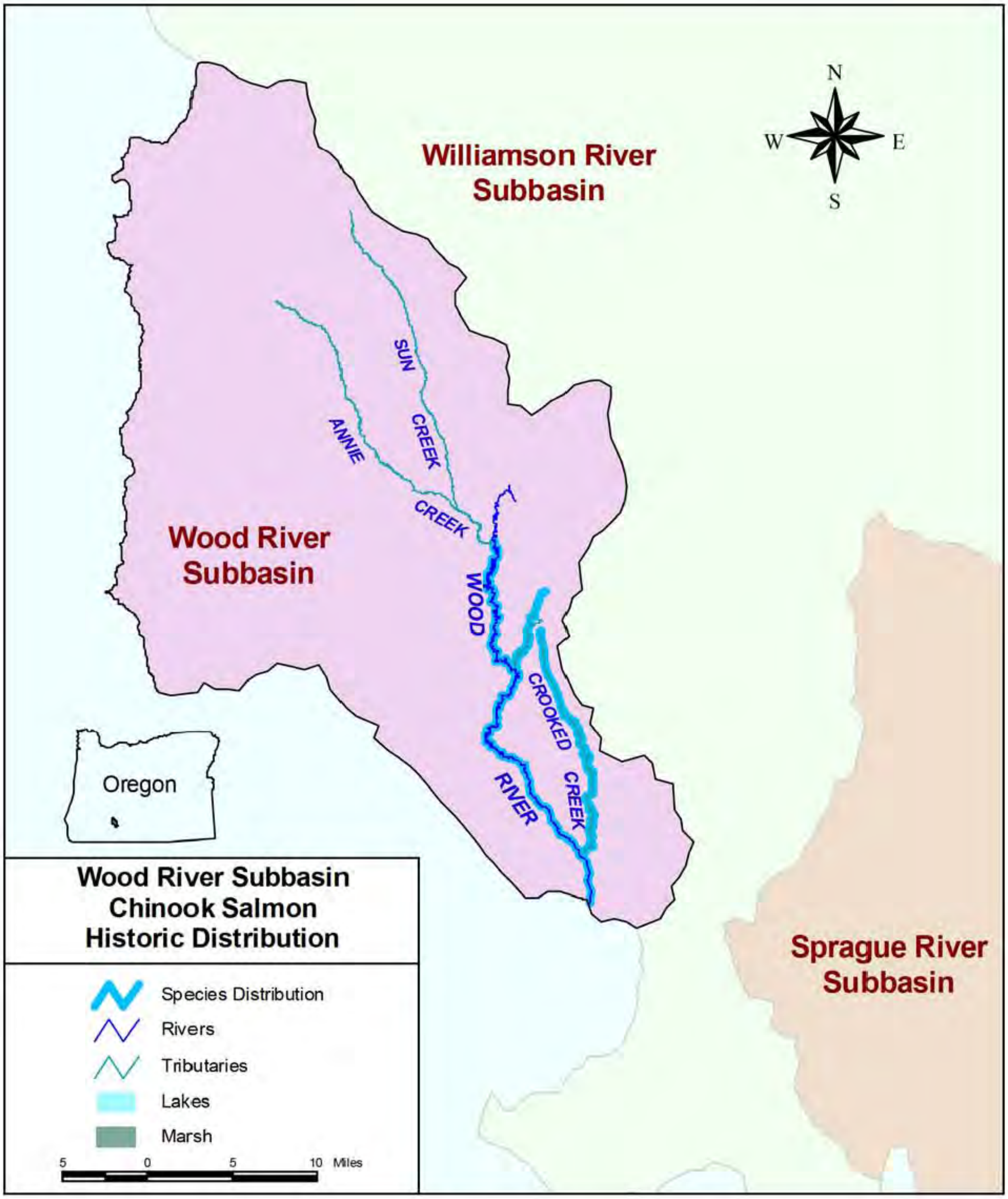


Figure VII-5f. Historic and anticipated Chinook salmon distribution in the Wood River subbasin.

179. Does only one of these life stages occur in a species at any given time?

No. Often, for a given location in a stream in a given month, some or all life stages are occurring simultaneously for the same species. For example, oftentimes you will find both the juvenile and adult life stages of a species within the same segment of stream. Across species, different life stages can likewise occur in a given location in a stream in a given month.

180. Why was it important to determine the life stage periodicities of the different species?

The monthly life stage periodicities of the target fish species factor into the derivation of the monthly Physical Habitat Claims. The flow recommended for a given month relates to a specific species and a specific life stage occurrence during that time. That is, different life stages for different species have different flow needs. Therefore, it was important to determine the lifestage(s) of each species for each month.

181. How did you identify the monthly lifestage periodicities for each of the target fish species within the Wood River subbasin?

Like determining the species distributions, the lifestage periodicities for the Wood River subbasin were determined based on a review of available published and unpublished information, and information gathered through contacts made with local fish biologists from the U.S. Forest Service, USBOR, USFWS, ODFW, and the Klamath Tribes. We relied heavily on periodicity information provided by ODFW, in particular, a series of periodicity tables prepared by Smith et al. 2003 (ODFW) (Ex. 281-US-409) and Messmer et al. (2000) (ODFW) (Ex. 281-US-410) that depicted species lifestage utilization for all of the major streams in the Upper Klamath Basin, including the Wood River subbasin. Using the combined information, we were able to construct lifestage periodicity charts that display the target fish species and the lifestage functions that occur during any month. This was first done for the entire Upper Klamath Basin and then refinements made to account for river subbasin specific differences. The lifestage periodicity chart for the entire Wood River subbasin is depicted in Figure VII-6.

182. Does the lifestage periodicity chart reflect the lifestage periodicities for the target fish species for each stream in the Wood River subbasin?

Yes. The chart is organized by species and includes separate periodicities for each species. Importantly, throughout our study of the Upper Klamath Basin, species distribution and periodicities were re-evaluated on an ongoing basis so that the most current information available was used as the basis for the Physical Habitat Claims. This resulted in some changes to the species periodicities that formed the basis for the 1997 and 1999 Physical Habitat Claims that are reflected in the Updated Physical Habitat Claims presented here through my testimony.

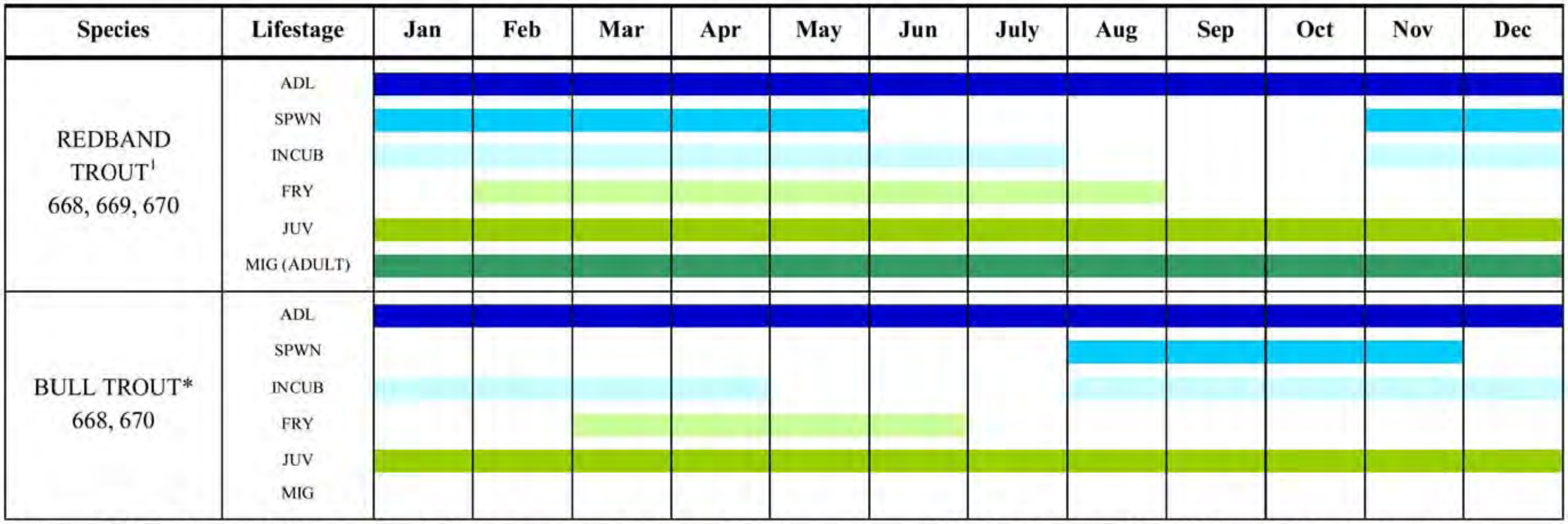


Figure VII-6. General life stage periodicity for target fish species, Upper Klamath Basin, Oregon–Wood River subbasin (sources of information and references are listed at the end of the figure).

[1]Includes both resident and adfluvial populations

*Historically present

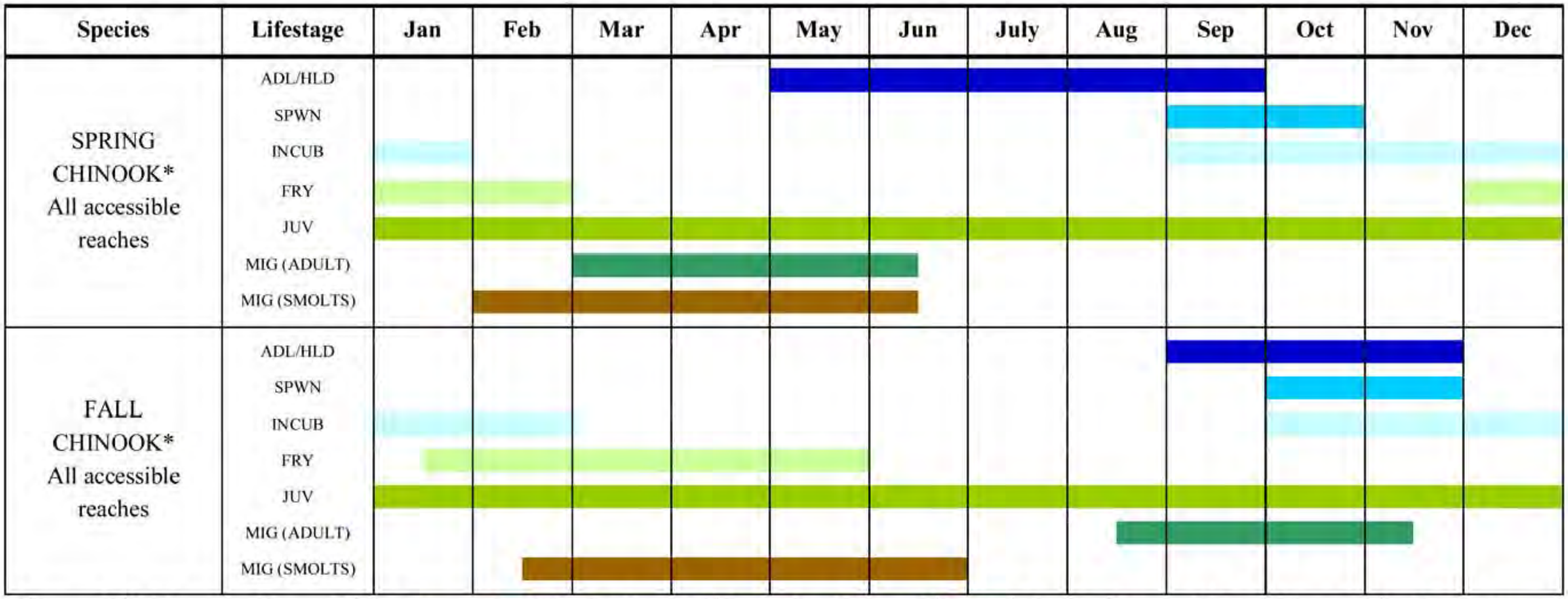


Figure VII-6 (cont). General life stage periodicity for target fish species, Upper Klamath Basin, Oregon–Wood River subbasin (sources of information and references are listed at the end of the figure).

[1]Includes both resident and adfluvial populations

*Historically present

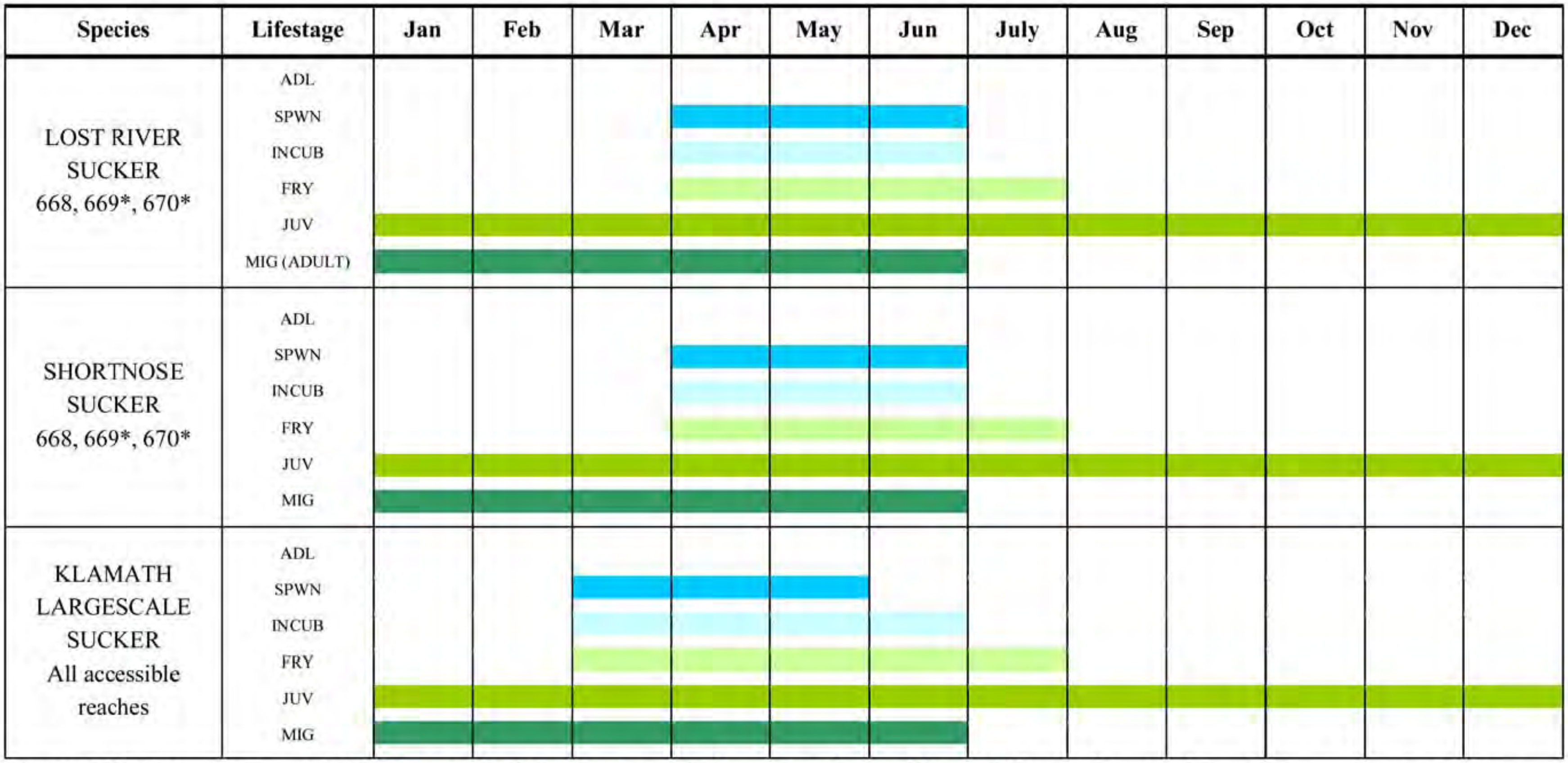


Figure VII-6 (cont). General life stage periodicity for target fish species, Upper Klamath Basin, Oregon–Wood River subbasin (sources of information and references are listed at the end of the figure).

[1]Includes both resident and adfluvial populations

*Historically present

Sources of information and references used to construct species periodicities:

FishPro 2000; Hamilton et al. 2005; Hooton and Smith 2008; Huntington et al. 2006; Messmer et al. 2000 (Ex. 281-US-410); NRC 2004; OWRD Ex. 2 pp. 1002-1005; and Smith et al. 2003 (Ex. 281-US-409).

183. Please describe Step 4 of the nine-step process – Determining the Lifestage and Species Prioritization.

Once the target fish species, distributions, and lifestage periodicities were established, we needed to determine how this information would be used in developing the Physical Habitat Claims. For any given reach of stream, there could potentially be up to five (under current conditions), or six (with future reintroduction of Chinook salmon) target fish species present. For any given month, multiple lifestages might exist for each species within the same reach. Step 4, therefore, focused on developing a prioritization framework from which to identify the appropriate lifestage and species that would be primarily considered for deriving each of the Physical Habitat Claims for any given month. This step required an understanding of the life history requirements and the biological needs of the target fish species.

184. Do flow needs change for a fish species by lifestage?

Studies have shown that the flow needs of fish vary by lifestage. Fry, for example, cannot withstand as high a velocity of water as can juvenile or adult fish and seek slower waters. Therefore, the amount of flow needed to provide fry habitat in a stream is typically less than that needed for juvenile and adult habitat. For spawning habitat, the amount of flow needed depends in large part on the location and amount of spawning gravel, and the amount of flow required to provide suitable water depths and velocities over such gravels. This may require different flows than those for either juvenile or the adult lifestages.

185. Why was lifestage important to consider?

Species prioritization alone does not lead to derivation of a specific monthly flow that provides for healthy and productive fish habitats. If we only based the claim on the highest priority species, which for some basins would be redband trout, the need would still exist to determine which lifestage should form the basis for the claim since multiple lifestages of various sub-species of redband occur during most months (see Figure VII-6). In addition, because the claim was to provide for the flow needs of all of the target fish species, consideration had to be given to the lifestages of other target fish species. This required a prioritization of the lifestages based on their biological importance in maintaining the population viability of the target fish species. Therefore, by considering the lifestages most important to maintaining a healthy and productive fish population, we prioritized the lifestages of fish. In turn, flow conditions tied to specific lifestages were established.

We reviewed habitat mechanisms likely influencing the populations of the target fish species. This resulted in the ranking of the lifestages from highest (most important) to lowest as follows: Spawning (first priority); Adult (second priority); Juvenile (third priority); and Fry (fourth priority). The process of prioritizing lifestages is commonly done as part of instream flow studies, and was the case for the two studies noted above, Clackamas River in Oregon (FERC 2006), and Sultan River in Washington (Reiser et al. 2009). Indeed, those two studies generally resulted in the same lifestage hierarchy as noted above. Afterwards, we identified and ranked those flow conditions that impacted lifestages and that could be quantified and analyzed as part of the IFIM/PHABSIM method.

186. Please explain the rationale for the ranking of lifestages.

The rationale for the hierarchy just noted pertains to the biological importance of the four lifestages with respect to flow needs. **Spawning** represents the reproductive component of a fish population and pertains to the future propagation of the various target fish species. Thus, we determined that the spawning lifestage should be given highest priority. As noted above, the amount of flow needed for this lifestage depends in large part on the flow required to provide suitable water depths and velocities over spawning gravels.

The **Adult** lifestage, ranked second, represents the factories or engines that produce the offspring needed to sustain a given population. Although the fish during this lifestage are not spawning, after they spawn they must continue to feed and grow in the meantime. Therefore, flows sufficient to create suitable adult habitat are needed to provide for healthy and productive fish habitats.

The **Juvenile** lifestage, ranked third, occurs between the fry and adult lifestages and encompasses the time when the fish is actively developing to when it reaches sexual maturity. The provision of flows that create habitats of sufficient quantity and quality must be maintained to promote growth and survival of juvenile fish.

The **Fry** lifestage, ranked fourth, occurs between egg emergence and the point at which they become juveniles. Because fry seek shelter in areas with low velocity and that contain abundant cover from which to avoid predators, fry habitat needs are generally met with flows much lower than those for the other lifestages. Fry habitat is generally not limiting in fish populations and, therefore, this lifestage was assigned the lowest priority. I observed no months in which the fry lifestage was the only lifestage present. Thus, the fry lifestage did not become a priority lifestage and no flow claims were based on the fry lifestage.

187. Were there any other lifestages considered as part of this prioritization?

Yes. We also considered the period of **Egg Incubation**. This period occurs immediately after spawning and extends through emergence of fry from the gravels. Egg incubation was considered to ensure that the flow conditions after spawning would remain suitable throughout the period of egg incubation.

188. As to the Physical Habitat Claims for target fish species currently present in the Upper Klamath Basin, were any species of primary importance?

All six of the target fish species are important for the Physical Habitat Claims, but in order to develop the updated Physical Habitat Claims, a species hierarchy was employed based on the cultural, ceremonial, and management values of the Klamath Tribes, as well as state and federal recovery and management goals. Assuming the species was present in a given claim reach, this hierarchy prioritized the species as follows: redband trout (first priority); Lost River sucker (second priority); shortnose sucker (third priority); Klamath largescale sucker (fourth priority), and bull trout (fifth priority). Chinook salmon, the sixth target species was given special consideration in that upon its reintroduction it would be given first priority. Because Chinook salmon is not currently present in the Wood River subbasin, the Physical Habitat Claims focused primarily on the next two priority species, redband trout and Lost River suckers. As mentioned above and as will be further described in Sections VIII and IX, because Chinook salmon was historically present in the Wood River subbasin and is likely to be re-introduced, conditional Physical Habitat Claims were also developed for those claim reaches that Chinook salmon historically utilized or it is reasonable to believe that they will utilize upon reintroduction into the Upper Klamath Basin.

189. As to the selection of target fish species, does this mean that the other species are not important or were not considered in developing the Physical Habitat Claims?

No. Although the focus on the claims may have been on certain species, development of the claims considered the species known to be present or historically present and with a likelihood of return to the basin in the foreseeable future (e.g., Chinook salmon). It would be impractical and unnecessary to perform an analysis of every fish species present in the Upper Klamath Basin. It has been my experience that instream flow studies routinely focus on the needs of several fish species considered as target species, rather than on every fish species present in a given river system. As described above, OWRD Ex. 2, pp 4 through 5 is a complete list of fish species known to exist or have existed in the Upper Klamath Basin.

190. Please describe how the species and lifestage priorities were used in developing a decision framework to derive the Physical Habitat Claims.

The decision framework involved consideration of both lifestage prioritization and species prioritization. The decision process for each month proceeded as follows: first, the months were identified in which spawning (highest priority lifestage) occurs for all of the target fish species present within the reach. The flow claims for those months were thus based on the spawning lifestages of the respective target fish species. Spawning overlap between two or more target fish species resulted in a Physical Habitat Claim based on the higher priority species. Thus, species prioritization was a secondary consideration implicated only if there was overlap for a given priority lifestage by more than one species.

Second, for months in which spawning does not occur, the months were identified in which adults were present. The flow claims for those months were based on the adult lifestage of the respective target fish species. Again, for any overlap for a given month between species, the flow claim was based on the higher priority species.

Third, for any months in which neither spawning nor adult lifestages occur, the months were identified in which the juvenile lifestage occurred. The flow claims for those months were based on the juvenile lifestage of the respective target fish species, with any overlap being dictated by the highest priority species.

191. Did the fry lifestage factor into the decision process?

As I described, the fry lifestage was a fourth priority lifestage. I observed no months in which the fry lifestage was the only lifestage present. Thus, the fry lifestage did not become a priority lifestage and no flow claims were based on the fry lifestage.

192. What level of protection did you assign to the incubation flows?

Incubation flows were developed for each stream in which spawning occurred and correspond to 2/3 of the previous month's spawning flow (Thompson 1972). The 2/3 fraction of flow provides flow conditions conducive to egg incubation such as maintaining sufficient water depth, oxygen content, and velocity (Thompson 1972).

193. How did the incubation lifestage factor into this decision framework?

As I described above, sufficient stream flow associated with protecting eggs and providing for their development during incubation must be provided to ensure a healthy and productive habitat. Therefore, egg incubation operated as a "shadow" lifestage to the spawning lifestages, and was considered in months immediately following a spawning month. Egg incubation became flow-determinative when the flow for the priority lifestage in that post-spawning month was less than that for the incubation flow.

Take for example, the hypothetical instance in which the flow for a given month might be based on Lost River sucker spawning. In the next post-spawning month, the priority lifestage and species might be the adult redband trout. If the necessary physical habitat flow for the redband trout adult in that second month were less than what would be required for Lost River sucker egg incubation (2/3 of Lost River sucker spawning flow), then for that second month, the flow claim would need to be based on the incubation needs of Lost River sucker eggs. Similarly, if the adult redband flow exceeded the Lost River sucker egg incubation flow, no change would be needed and the claim would be based on the flow needs of the adult redband trout.

194. Have you applied this lifestage and species prioritization on any other projects?

Yes. As noted above, this procedure has been used on several other recent instream flow projects (e.g., Clackamas River, Oregon; Sultan River, Washington) that were related to the relicensing of hydroelectric facilities. The prioritization process was used to establish the Physical Habitat Claims filed in 1997 and 1999, and ultimately the updated claims presented here through my testimony.

195. Did you check on whether the flow claims you derived from this process were impacting other lifestages and species?

Yes. As part of the Physical Habitat Claim development process, we incorporated an evaluation procedure to ensure that a Physical Habitat Claim would not act to the significant detriment of another species' lifestage. For example, if the Physical Habitat Claim for one month was based on redband trout spawning, and other lifestages of target fish species were also present in that system at the same time, we reviewed the claim with respect to the habitat:flow relationships for the other lifestages and species to ensure that the flow would still provide suitable amounts of habitat for them. The specific details of this procedure are presented in Section VIII.

196. Please describe Step 5 of the process-Development of Species Habitat Suitability Criteria (HSC) Curves.

In Step 5, we developed species-specific habitat suitability criteria curves (HSC curves). HSC curves are a necessary component of the IFIM/PHABSIM modeling process that must be identified and/or developed to ultimately generate the necessary habitat:flow relationships. In fact, this step and the next two (Steps 6 and 7) all relate directly to data, information and modeling that all contribute to the computer modeling associated with PHABSIM.

197. What are Habitat Suitability Criteria (HSC) Curves and why are they important?

This is best answered by first discussing briefly one of the end products of the IFIM/PHABSIM analysis. The end product of the IFIM/PHABSIM analysis is a habitat:flow relationship curve that plots the amount of habitat in a stream (Y-Axis expresses as weighted useable area ("WUA")) against possible stream flows (X-Axis expressed in cubic feet per second). Figure VII-3 (presented earlier in this section) provides an example of four typical habitat:flow relationship curves overlaid onto each other. WUA is the amount of square feet of habitat across a cross section of a stream per 1,000 linear feet of stream.

Based on field data, we calculated and used these relationships to guide the selection of the Physical Habitat Claims. The important point here is that different relationships exist for each target fish species and each lifestage. Figure VII-3 depicts specific habitat:flow relationships for each redband trout lifestage – adult, juvenile, fry, and spawning in claim Reach 668. The HSC curves were used in the computer modeling process to generate habitat:flow relationship curves.

198. Why are there different relationships for each species and lifestage?

Each species and lifestage combination has unique requirements or tolerances for velocity, depth, and substrate combinations in a stream. For example, as noted above, fry prefer slow velocities, while juveniles and adults may select higher velocities in combination with certain depths. The spawning lifestage depends on ranges of velocities in conjunction with suitable water depths and substrates. These different requirements or tolerances for velocity, depth, and substrate combinations, when integrated into the IFIM/PHABSIM process result in different habitat:flow relationships.

199. How are these different requirements represented and integrated into the IFIM/PHABSIM analysis?

That is where the HSC curves come in. In essence, the HSC curves are probability functions that depict the velocity, depth, and substrate preferences of fish for each species-lifestage combination. In other words, HSC curves represent how suitable a particular water velocity, water depth, and substrate type in a stream is to a target fish species during a specific lifestage. The HSC curves contain numerical values that reflect these probabilities. These probabilities are then linked with the PHABSIM computer models resulting in the derivation of the habitat:flow relationships found in the WUA graphs that show the amounts of habitat at various flows for each target fish species and lifestage.

200. What do HSC curves look like?

Figure VII-7 is an example of two HSC curves used for target fish species (velocity and depth curves overlaid on top of each other and displayed in a single figure). The curves represent the suitability of water velocities and water depths for redband trout spawning. As shown, the HSC values range from 0 (unsuitable) to 1.0 (optimal or preferred) with probability on the Y-axis and units of measurement (depth or velocity) on the X-axis. HSC curves of similar form were developed and used for each lifestage of each target fish species. Once developed, HSC curves could be used for a species or lifestage in any stream/river in the Upper Klamath Basin.

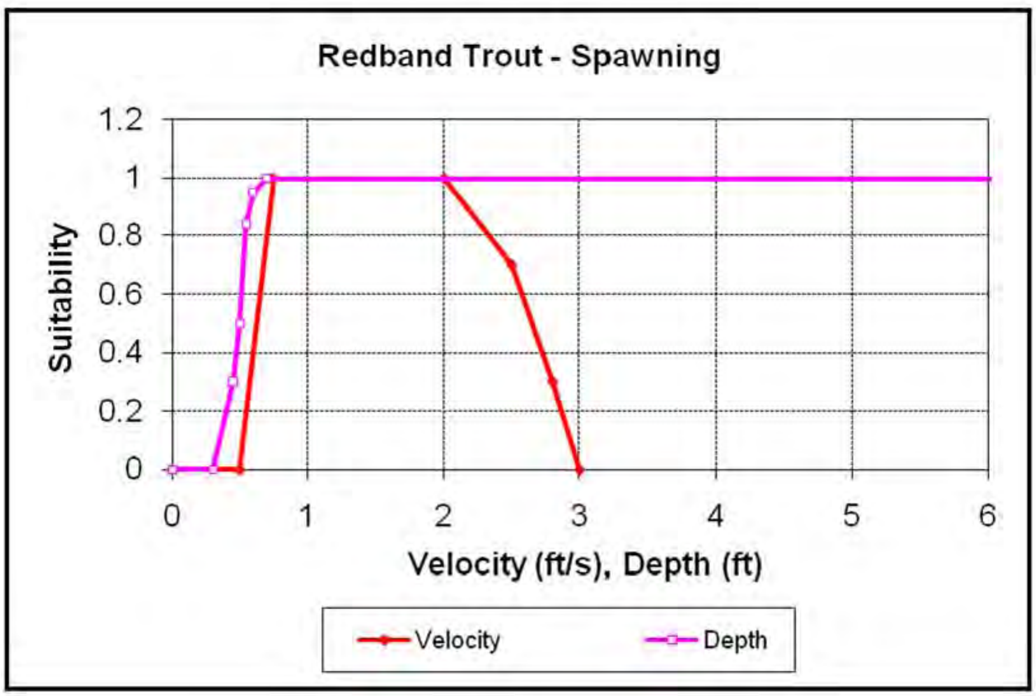


Figure VII-7. Habitat suitability criteria (HSC) curves for redband trout spawning. Here, the depth HSC curve is presented together with the velocity HSC curve.

201. Is there a standard approach or methodology for developing HSC curves that is generally followed by IFIM/PHABSIM practitioners?

Yes. HSC curves are developed based on factors that are project-specific including the availability of existing data, the feasibility of collecting new data, and the time available.

Several avenues can be followed for deriving HSC curves. The U.S. Geological Survey (USGS)[2] classifies HSC curves into three categories (Categories 1, 2, and 3) based on the types of data used (Bovee 1986). Category 1 curves are derived from personal experience and professional opinion, from literature based curve sets, or from negotiated definitions. Category 2 curves are based on frequency distributions of site-specific data that reflect microhabitat attributes measured at locations used by the target fish species. Category 3 curves also rely on site-specific data and are designed to factor in the availability of certain habitat attributes into the curves thereby reducing bias. A more detailed description of these curve types and procedures for HSC criteria development is available from the USGS website: (http://www.fort.usgs.gov/products/Publications/15000/chapter3.html#categories).

202. Did you use any of the three USGS categories to develop the HSC curves for the Upper Klamath Basin?

Yes. In fact, we used a combination of approaches including the compilation and review of literature-based HSC curves applied in other studies, round table discussions with regional and local experts, and the collection of site-specific data.

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2 The U.S. Geological Survey (USGS) is the agency within which the original developers of the Instream Flow Incremental Methodology (IFIM) and PHABSIM reside. The USGS is responsible for the dissemination and production of all technical information related to the IFIM/PHABSIM methods.

203. Please explain briefly what was done in your HSC curve process.

For the Upper Klamath Basin, we compiled and reviewed more than 100 HSC curve sets that had been developed and used on other investigations. These curves were organized by species and lifestage and distributed to fish experts knowledgeable in the lifestage requirements of the target fish species. Each expert was subsequently invited to a round table meeting at which a consensus was reached on a set of draft HSC curves for the target fish species except bull trout. For that species, a separate meeting of bull trout experts was convened, representative HSC curves reviewed, and a consensus reached on the bull trout HSC curves for use in the Upper Klamath Basin.

Since that time, we have updated the HSC curves based on site-specific microhabitat data we collected for a number of target fish species and lifestages. This primarily involved field studies that were completed during the summer and fall of 1998 and 2003 in the Upper Klamath Basin. During these studies, snorkel observations were made to observe where fish were residing and the velocity, depth, and substrate measurements were taken at these locations.

204. What do you mean by snorkel observations?

One of the ways in which fish biologists locate and observe fish is to submerge themselves in a stream with mask, snorkel, and protective outer-wear. The general process is for the snorkeler to move slowly in an upstream direction to locate a fish, mark the position of the fish, and then have a second person take depth and velocity measurements at that particular site.

205. Are there standard approaches for collecting snorkel-observation data?

Yes. We generally followed the methods and procedures as outlined by Bovee (1986).

206. Did you collect any other types of data?

Yes. We took fish depth measurements, stream velocity measurements, and when active spawning areas containing egg nests (redds) were visually located, we also took depth, velocity, and substrate measurements.

207. How many measurements of each type of observation did you make?

A tabulation of the number of observations made during 1998 and 2003 surveys is presented in Table VII-4 by species and lifestage.

Table VII-4. Summary of the number of microhabitat use observations (fry, juvenile, adult) and measurements (egg nests/redds) made during site specific surveys to confirm and/or modify literature based HSC curves for the Upper Klamath Basin, Oregon.

Species	Lifestage	Number of Observations/Measurements
Redband Trout	Fry	301
	Juvenile	145
	Adult	196
	Spawning (redds)	149
Bull trout	Juvenile	6
	Adult	18
Lost River Sucker	Adult	31

208. How were those observation data used?

These site-specific data were analyzed and used to revise and update the previously applied HSC curves to better reflect the habitat characteristics that are actually being utilized by the target fish species in the Upper Klamath Basin. In some cases, the changes to the HSC curves were small, in others, the changes were greater.

For example, Figure VII-7 below illustrates the changes made to the original HSC curves for redband spawning based on the collection of site-specific data. In general, as a result of the collection and analysis of site-specific data, there was a shift toward a lower range of velocities considered as optimum, but essentially no change in the depth suitability curve.

Figure VII-8 first shows that redband trout prefer water depths at or greater than 0.75 ft at which suitability reaches optimum (suitability level 1). Figure VII-7 also illustrates how with more site specific Upper Klamath Basin data, the optimum water velocity *decreased* in range from between 1.75 ft/s and 3 ft/s to 0.75 ft/s and 2 ft/s (comparing original and revised velocity lines).

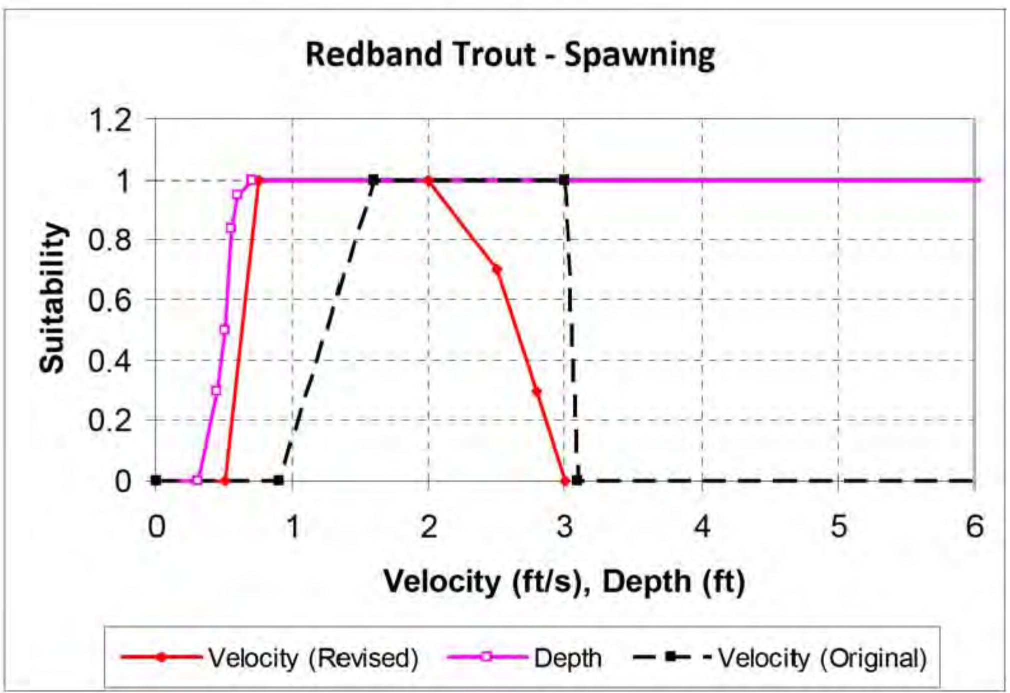

Figure VII-8. Habitat suitability criteria (HSC) curves for redband trout spawning, comparing coordinates from the HSC curve used for the 1997 and 1999 claims, with the revised HSC curve developed subsequently and used for the updated Physical Habitat Claims.

Ex. 281-US-415 contains copies of all of the final HSC curves used in deriving the Physical Habitat Claims for the Wood River subbasin.

209. Please describe Step 6 of the process – Field Data Collection.

With all of the information described in the first five steps either assembled, in the process of being assembled, or identified as necessary to be determined, we initiated Step 6, which is the Field Data Collection component needed for the IFIM/PHABSIM process. This step was completed at different intervals over the course of the Upper Klamath Basin study. The largest IFIM/PHABSIM field data collection efforts occurred from the fall of 1990 to the summer-fall of 1991 and in the summer-fall of 1993. A number of the original sites were re-sampled in 2004, and, since then, a number of field data collection sites were added to capture unique areas (e.g., spawning riffles), to provide additional sampling within relatively long claim reaches, and most recently in 2009, to collect field data from one site (Whisky Creek Claim Reach 649, Sprague River subbasin, case #280 Klamath Basin Adjudication) for which prior access restrictions prevented field data collection.

210. Who collected the field data?

Field data were collected by EA or R2 field crews under my direction, consisting of 2-3 individuals for smaller wadeable streams, and 3-4 individuals for larger streams requiring a raft for data collection. Field crew leaders all had extensive training and experience in stream surveys and collecting IFIM/PHABSIM data and all crew members were given instructions on sampling and survey protocols.

211. What methods did you use to collect the IFIM/PHABSIM data?

We used standard methods recognized in the field for collecting IFIM/PHABSIM data. The data collection sequence implemented in the field is listed below, followed by a more detailed description. These steps generally followed the standard procedures outlined by Bovee and Milhous (1978), Trihey and Wegner (1981), Bovee (1982), and Bovee et al. (1998).

Under step 6, the general sequence for collecting IFIM-PHABSIM data involved the following steps:

Step 6.A – Locate the candidate site from the site descriptions and maps;
Step 6.B – Randomly select the starting point of the study site;
Step 6.C – Map habitat in an upstream direction (25 average channel widths);
Step 6.D – Select habitat types to be measured;
Step 6.E – Select 3 transect locations within selected habitat types;
Step 6.F – Establish and survey transects, headpins, working pins, and bench mark;
Step 6.G – Survey level loop and water surface elevations;
Step 6.H – Collect bed profile and depth and velocity measurements; and
Step 6.I – Data reduction for modeling and Quality Assurance and Quality Control

212. Please describe more specifically the IFIM-PHABSIM field data collection sequence.

Step 6.A and 6.B regarding site and starting point selections are straightforward. As described earlier, a candidate study site was selected and marked for habitat mapping on a 1:24,000 topographic map (i.e., map scale equivalent of 1 inch = 24,000 inches or 1 inch = 2000 ft). The general site location was established in the field with the actual starting point of the study site determined randomly. Each of the study sites had its own field book; the crew leader began a new field book at each site and filled-in basic information such as basin number, stream name, site location and directions, field crew members, and equipment used.

Step 6.C established sample sites (selected in Step 6.A and B) approximately 25 mean channel widths long. This was done to conservatively capture the variability of habitat types that typically become repetitive within 5 to 7 channel widths (Leopold et al. 1995). The crews began habitat mapping from the upstream end of a study reach for a length of approximately 25 bankfull-channel-widths. The necessary distance to map was determined while mapping, by periodically measuring 10 channel widths using a tape or stadia rod (survey rod that has increments of length etched on the side) in most cases.

Stream habitats can be characterized as follows: Pool, Run/Glide, Riffle, Cascade or Island (see Table VII-5). The linear stream distance of each habitat unit was measured to determine the total percentage that the habitat made up of the study reach. Where the channel was not wadeable (for example because of high spring runoff), the channel width was estimated using a measured reference point (e.g., highway bridge, trail bridge, etc).

Table VII-5. Classification of habitat types used in the Wood River subbasin (based on Bisson et al. 1982; USFS 2001; Pleus et al. 1999).

Habitat Type	Description
Pool	Water velocity relatively low, non-turbulent. Relatively deep, with distinct longitudinal depression in streambed. Water surface gradient very low; water level determined by a distinct hydraulic control.
Run/Glide	Relatively fast but non-turbulent flow; relatively deep, but fairly uniform in depth; steeper gradient than pool, less steep than a riffle, slightly influenced by a hydraulic control.
Riffle	Water velocity relatively high. Relatively shallow; water surface gradient high, but water level not determined by distinct hydraulic controls. Considerable surface turbulence; zero depth at zero discharge.
Cascade	Water velocity high with shooting flows and considerable turbulence. Hydraulic controls closely spaced. Frequent obstructions by large substrate. Gradient steeper than for a riffle. May contain pocket water.
Island	Single or more vegetated islands creating multiple (one or more) channels with complex, variable habitats within each channel.

In Step 6.D, a single habitat unit of each type of habitat accounting for greater than 10 percent of the study reach was randomly selected for sampling. The 10 percent criterion was created based on the reasonable belief that habitat types accounting for less would have a negligible effect on the overall flow recommendation. The exception to this 10 percent criterion was made for what we considered "critical" habitats, such as small falls or cascades or limited spawning areas, for which flow changes could influence their use. These areas were sampled even though they may have represented less than 10 percent of the total study reach.

In Step 6.E (select three transects), by applying a random selection process to avoid bias, crews determined the habitat unit(s) to be measured and studied. Once identified, three transects were located within each selected habitat unit for sampling. For pool habitats, the crew also located and placed a fourth transect across the hydraulic control of the pool point in a stream that, based on channel form, likely controls the water surface elevation of the pool for some distance upstream to the next control point for hydraulic modeling purposes.

213. For the field data collection Step 6.A-C you have thus far described, please provide an illustrative example of how the field data collection steps were followed?

I will describe the field data collection steps associated with Claim Reach 668 on the Wood River subbasin. The study site was first identified from maps and through consultation before anyone was sent to the field (Field Data Collection Steps A and B). Once in the field, the stream widths at the study site were measured and found to be an average of 56.6 feet wide. Thus, the study reach was determined to be 1415 feet long (56.6 ft x 25 channel widths) (Field Data Collection Step 6.C). Walking upstream, ten riffles and eleven pool habitat units (i.e., 21 habitat units), were identified within the site. The total length of the riffle units comprised 56.8 percent of the site length and the pool units comprised the remaining 43.2 percent of the sample site length. One riffle and one pool habitat unit was then each randomly selected for collecting depth, velocity, and substrate data across transects (Field Data Collection Step 6.D). Three transects were then randomly placed across the river in each sample unit, for a total of 6 transects at that site (Field Data Collection Step 6.E).

214. Please describe Steps 6.F (Establish and Survey Transects, Headpins, Working Pins, and Bench Mark), and 6.G (Survey Level Loop and Water Surface Elevations).

Step 6.F involved the surveying of transects. Once the transect locations were identified, a benchmark (BM) pin was established for each habitat unit. Next, rebar (metal rods) headpins were installed in solid, stable bank material to mark transect locations above the high water mark. Wooden stakes were driven into the ground next to the rebar headpins on each bank (or fence post if boat and cable were used), and were used as working pins for the transect location. Further, these working pins were placed so that the transect would be perpendicular to the flow direction and where water surface elevations (WSEs) were reasonably similar on both sides of the channel. With working pins in place, survey tape was extended between and attached via clamps to the working pins to allow measurements to be made at the same locations across each transect. Figure VII-9 illustrates a cross-sectional view of a transect location for Claim 668. Figure VII-10 illustrates general transect placements used in this study over different habitat types, including those for pool habitats.

With the transects set, we moved to Step 6.G, and completed a survey level loop and water surface elevation (WSE) measurements. The survey level loop ensured accuracy of surface elevation measurements and was performed before data collection began. The survey level loop simply involved taking elevation measurements of the bench mark, headpin elevations, and fixed locations. This process checks for any changes in headpin elevations that may occur during and between survey periods. Finally, after the survey level loop was successfully completed, WSEs were surveyed following standard surveying practices.

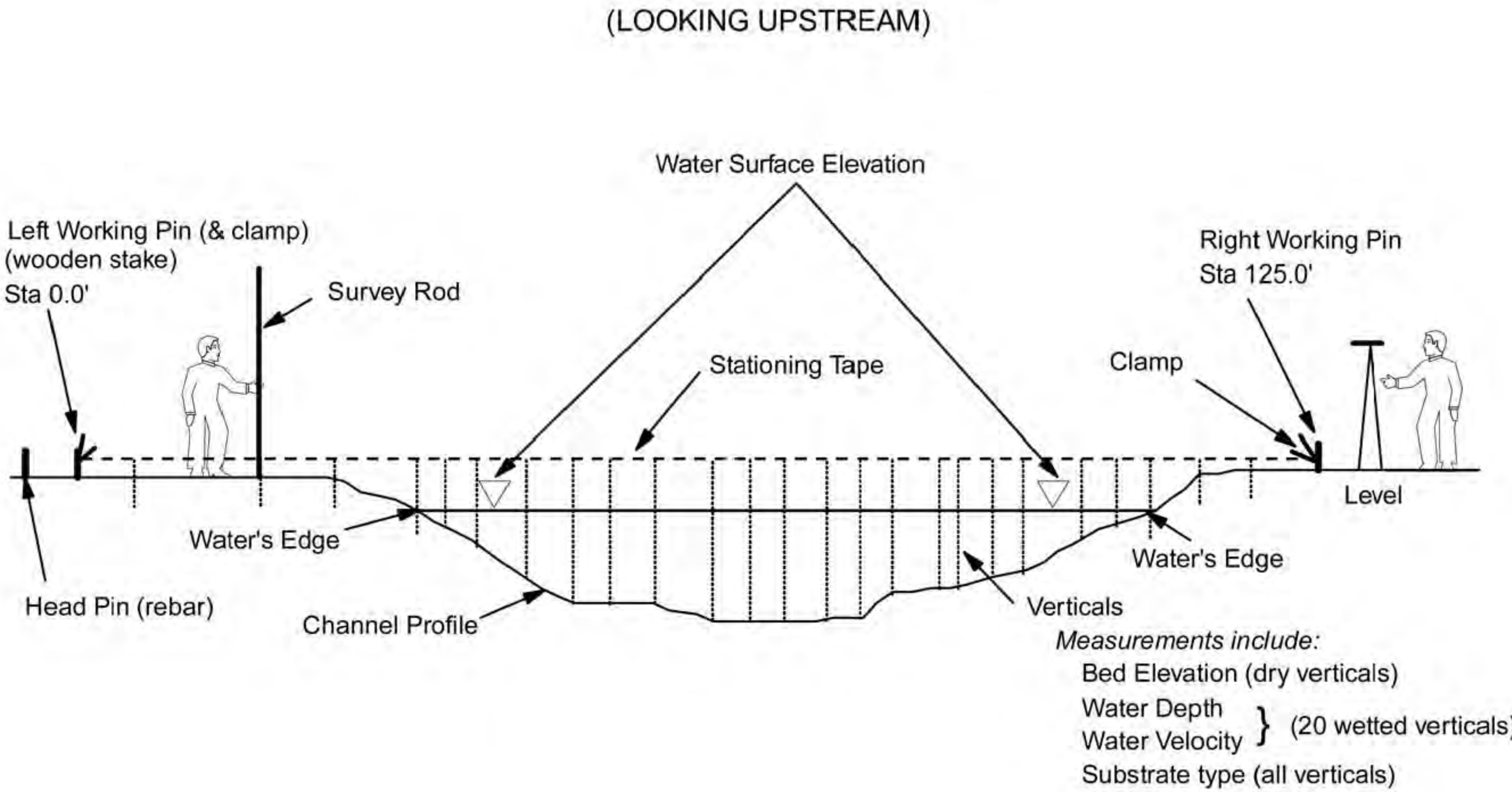

Figure VII-9. Cross-sectional illustration of IFIM/PHABSIM transect organization and measurement points during the development of the Physical Habitat Claims.

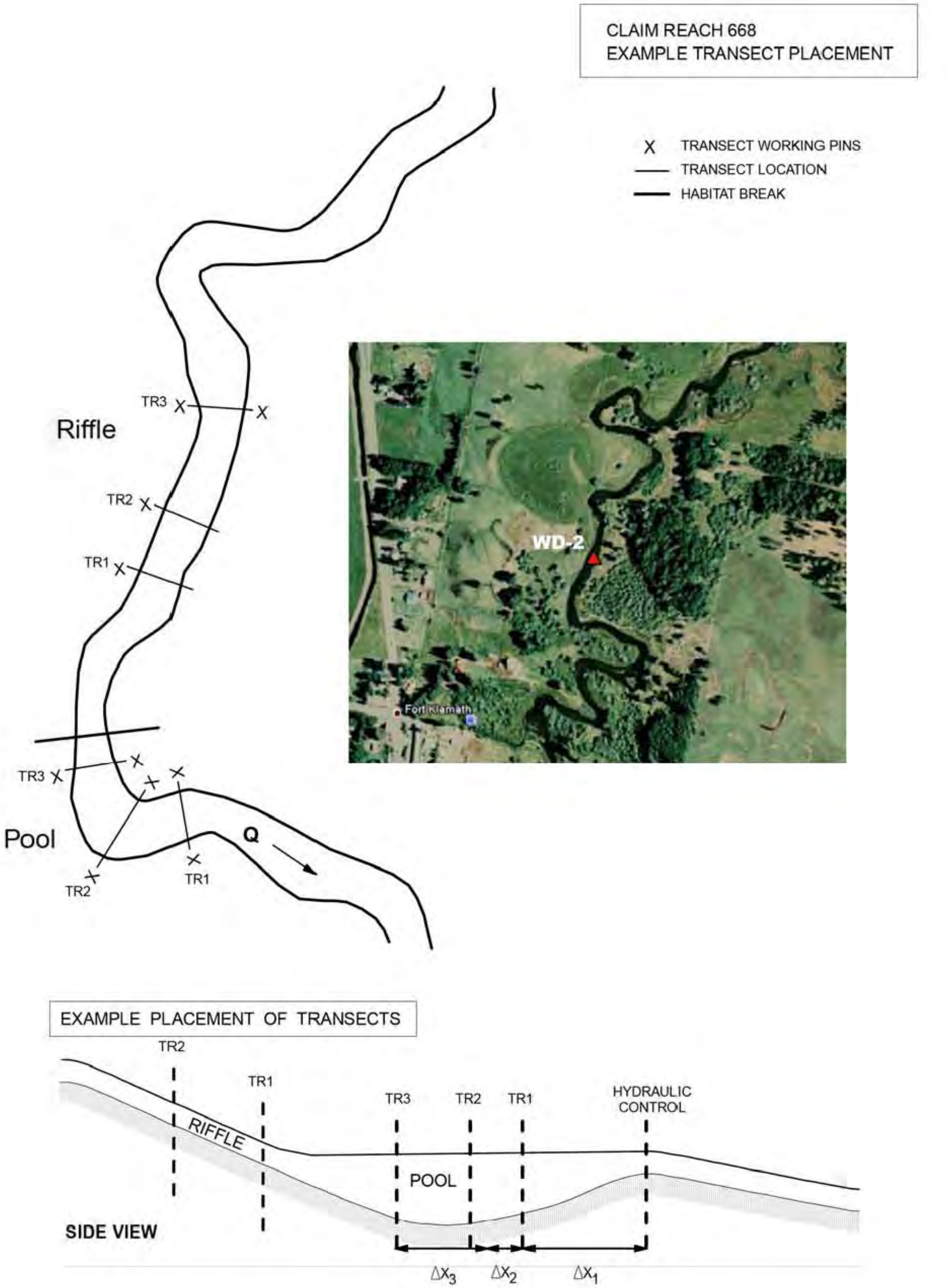

Figure VII-10. Illustration of transect placements in representative habitat units within Claim 668 study site

215. Please describe Step 6.H (Collect Bed Profile and Depth and Velocity Measurements).

Step 6.H involved collecting bed profile data and depth and velocity measurements. Here, the transect's bed profile was surveyed and recorded once with a stadia rod that is placed on the streambed at short regular intervals. Also, flow velocity and water depth were measured at regular intervals across the transect (each interval referred to as "verticals" or "cells") using a Swoffer Model 2100 current meter and topset wading rod. (see Figure VII-9). For larger streams, at least twenty wetted verticals were measured. For smaller streams less than 20 feet wide, depth and velocity measurements were spaced either every foot or at ten verticals, whichever was greater. Small stream measurement locations were chosen to capture the cross-channel variation in velocity and bed elevation, rather than using regular spacing which can miss important habitat features. In the process of gathering stream measurements, representative photographs were taken of each study site during each field effort.

Most study reaches were visited three times to collect IFIM/PHABSIM data at three different flow stages. Data collection intensity was highest during the first field visit and included habitat mapping, transect selection and setup, level-loop surveys, and bed profile, depth and velocity measurements. Depth and velocity measurements were generally completed on all transects at two out of three visits, with only stage and discharge data measured on the remaining visit. When only stage and discharge data were collected, at least one cross-section was measured for depths and velocities to obtain the discharge measurement. This cross-section was located where possible in run-like habitat, which typically provides the most uniform flow conditions for discharge measurement.

216. Please describe Step 6.I (Data Reduction for Modeling and Quality Assurance and Quality Control).

All aspects of the study including data collection, data reduction and analysis, and modeling were subjected to a quality assurance and quality control process that was included in the final step noted above, Step 6.I. The data collection steps described above were instituted and followed to ensure that data were accurately collected during each survey.

217. Returning to the nine-step process, please describe Step 7 – Instream Flow Hydraulic and Habitat Modeling.

With the necessary stream measurements collected from the sample sites within each claim reach of the Wood River subbasin (Claims 668 through 670), Step 7 involved applying the necessary IFIM/PHABSIM computer models to determine the relationships between the quantity of water flowing in the stream and the quantity of habitat for each of the target fish species and lifestages. As previously described, habitat quantity within a stream was expressed as weighted usable area (WUA).

218. Please describe any linkage between the collection of field data and the application of the computer models.

The IFIM/PHABSIM process involves the collection of field data that describe the hydraulic and physical characteristics of the stream at several different flows. These data serve as input to a series of computer programs that allow for the predictions of hydraulic and physical characteristics at various flows. This flow-extrapolation is a central feature of IFIM/PHABSIM that allows the derivation of habitat and flow relationships. The development of the computer models used to make these flow extrapolations was completed by the USGS. The models are available on the Internet with the USGS and we utilized one of the USGS-approved versions (DOS-based version V 2.1 JULY, 1989) for our modeling.

219. Are there standard procedures to follow when using these models?

Yes. The USGS has provided an extensive collection of documents that serve to guide users of the IFIM/PHABSIM system including those of Bovee et al. (1998), Bovee (1982; 1986), and Milhous et al. (1984).

220. Were those procedures and methods followed in completing the IFIM/PHABSIM modeling for the streams in the Upper Klamath Basin?

Yes. I have been trained in the application of the IFIM/PHABSIM models and have worked directly with them. In this case, the application of the IFIM/PHABSIM models, hydraulic model calibrations, and the production of the habitat:flow relationships were completed under my direction, and the direction of Mr. Michael Ramey, P.E. because of his extensive experience in hydraulic modeling. Mr. Ramey provided technical oversight and supervision of two other senior hydraulic engineers who were responsible for development and calibration of all hydraulic models used in the IFIM/PHABSIM analysis. Specific methods and procedures applied as part of the model development and calibration process are described in Mr. Ramey Direct Testimony at questions 19 and 21. Once the models were calibrated, I worked directly with the modelers in selecting the appropriate HSC curves to use in developing the species and lifestage specific WUA versus flow relationships used in deriving the Physical Habitat Claims.

221. What was the final result of the IFIM/PHABSIM modeling?

The IFIM/PHABSIM analysis combined the field data and the HSC criteria. As I have previously described, the end product of the IFIM/PHABSIM hydraulic and habitat modeling was a series of habitat:flow curves (expressed in an x-y graph with WUA along the y-axis and flow expressed along the x-axis). These curves graphically depict the habitat:flow relationships for each transect, for each lifestatge of each target fish species. The habitat-flow relationships (by species and lifestage) that were developed for each of the three transects of a specific habitat type/unit were subsequently averaged (1/3 each). A composite habitat-flow relationship (for each species and lifestage) was then developed for the study site by applying a weighting factor based on the percentage composition of each habitat type derived from the reach habitat mapping (see question 213). An example of one of these habitat:flow relationships was presented in Figure VII-3. This figure describes the four habitat:flow relationships for the four lifestages of redband trout in Claim Reach 668. Similar figures were generated for each of the Wood River claim reaches for each species.

222. Please describe Step 8 of the nine-step process – Hydrologic Limitations.

Step 8 involved identifying and applying a connection between the hydrology of the Upper Klamath Basin and the habitat:flow relationships derived from the IFIM/PHABSIM modeling. Every stream has a hydrologic regime that essentially describes the general timing and magnitude of flows that occur within the system. This hydrologic regime can be represented in a graph that shows how the flows are distributed over time (or hydrograph). Figure VII-11 is an example of one of the Wood River hydrographs (for Claim 668) developed and used during the claim development process. The figure depicts flows on the y-axis and months on the x-axis.

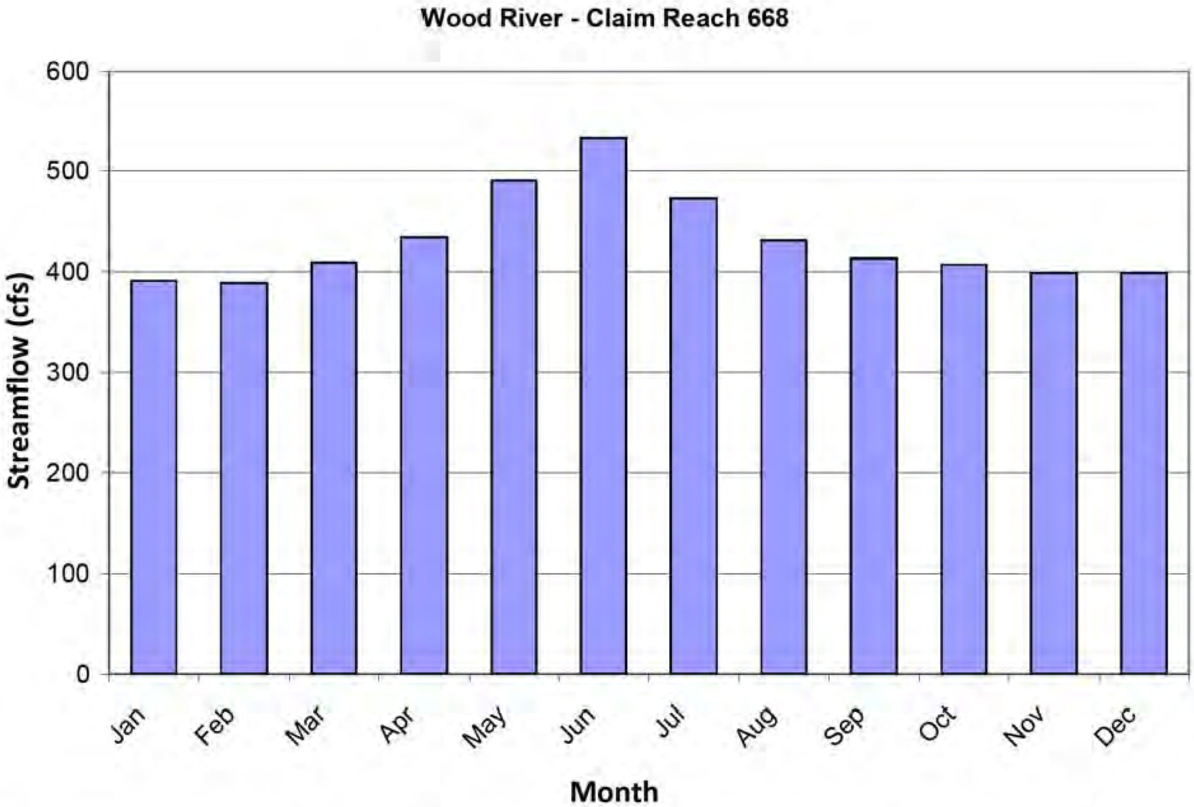

Figure VII-11. Wood River monthly hydrograph (median flow values) at high water confluence with Agency Lake (Claim Reach 668) (Source: Cooper 2004).

223. Why was this information relevant for developing Physical Habitat Claims and how was this incorporated?

A criticism of the IFIM/PHABSIM methodology is that habitat:flow relationships may or may not fit within the hydrological regime of a system. The critical argument goes that an IFIM/PHABSIM analysis projects habitat:flow relationships over a range of flows, some of which might not realistically ever occur within the stream system. Consideration and use of Upper Klamath Basin specific hydrologic information ensured that the derived habitat:flow relationships would fit within the hydrologic regime of the Wood River system as we did not want to recommend a flow that never occurred, or that occurred so infrequently that it would not be biologically meaningful.

224. How did you factor the hydrologic regime of the Wood River subbasin into the development of the flow recommendations?

I consulted with Michael Ramey, principal hydraulic engineer in our office, regarding the hydrologic statistics for each claim reach. Mr. Ramey reviewed the hydrology that had been developed by OWRD for streams of the Upper Klamath Basin. He identified and provided to me the reliable hydrologic statistics available for the Upper Klamath Basin. Working with Mr. Ramey, I concluded that the natural monthly median exceedance flow estimates developed by OWRD were a reasonable upper limit on the Physical Habitat Claims. This upper limit represented a conservative upper limit on the Physical Habitat Claims that would nonetheless provide the amount of water necessary, and no more, for a healthy and productive habitat for the target fish species. This upper limit also ensured that the developed PHABSIM habitat:flow relationships were hydrologically connected to the streams of the Wood River subbasin.

225. How was this hydrologic statistic applied in developing the instream flow recommendations?

The IFIM/PHABSIM derived habitat:flow relationships are based in large part on physical and hydraulic characteristics of the channel. These characteristics provide a means for incrementally evaluating how the relative quantity of habitat in a specific channel might change relative to changes in flow. In theory, one could review the modeled relationships (expressed graphically as WUA versus flow curves) and select the value on the WUA curve that simply provides the most living space for a given species and lifestage for a particular month. However, absent hydrology information, this could lead to the erroneous selection of a specific monthly flow that may never occur or only rarely occurs in the system. Using the WUA:flow relationship for Claim 668 as an example (Figure VII-3), if the IFIM/PHABSIM derived maximum habitat flow is 125 cfs, but the stream hydrology reveals that 125 cfs occurs every 20 years, then there would be little biological justification for that flow.

For these reasons, the Physical Habitat Claims have been conditioned on both the physical habitat that the stream channel provides as well as the stream flow (hydrology) that the system generally provides. The Physical Habitat Claims presented as part of my testimony today are limited in every instance to the *lesser* between the PHABSIM-derived flow and the monthly median flow. In other words, at no time does any Physical Habitat flow recommendation exceed the monthly median flow as calculated by OWRD.

226. Could the IFIM/PHABSIM habitat:flow relationships alone be used to develop physical habitat:flow claims?

In theory, yes. IFIM/PHABSIM habitat:flow relationships could alone form the basis for physical habitat:flow claims. As I mentioned, one could review the curves and select the value on the WUA curve that simply provides the most living space for a given species and lifestage for the particular month. This approach, often called "peak of the curve" approach, is based on the premise that the stream channel characteristics alone serve as the physical template behind the resulting habitat:flow relationships. Strict reliance on the peak of the curve would be followed under the assumption that the potential maximum fish production of a system can only be achieved when the amount of habitat is maximized. Thus, the "peak of the curve" becomes the recommended flow. We did not strictly rely on the peak of the curve, but rather we conditioned the habitat flows based on both the physical habitat that the stream channel provides as well as the streamflow (hydrology) that the system generally provides.

227. From where did you gather your hydrology information for the updated Physical Habitat Claims?

For the streams in the Upper Klamath River Basin, we relied on the hydrology for each of the basins as developed by OWRD (Cooper 2004). This information was not available when the BIA submitted its amended Physical Habitat and Riparian Habitat Claims in 1999. Once this information became available in 2004, we completed a detailed review and evaluation of the OWRD hydrology in developing the updated Physical Habitat Claim. The review and evaluation was led by Mr. Ramey and is described in Mr. Ramey Direct Testimony at questions 42 through 45.

228. Please describe Step 9 of the nine-step Physical Habitat Claim process – Other Flow Considerations – 1999 Amended Flow Claims Limitations.

In addition to the consideration given to the median flow (median flow values), the 1999 amended Physical Habitat Claims represent an absolute limit to the Physical Habitat Claims even when the latest results of our analysis suggests greater flow than the amount claimed in 1999. In the claims where this limit is reached, I reviewed the extent to which the 1999 claimed flow value would be less than the flow indicated by our updated analysis, and then evaluated whether the 1999 flow limit would still provide for healthy and productive habitat; I concluded that, in those few instances, they would.

229. With the nine-steps completed, what was your next course of action to develop the Physical Habitat Claims?

With the above nine steps completed, we were able to assemble and apply the information generated in a measured way to update the specific monthly Physical Habitat Claims for each of the 3 claim reaches identified in this case. Therefore, my final actions were to identify the specific flow levels for each claim reach using the large body of information and data assembled. This was done in a final decision-logic sequence described in Section VIII.

230. Was the work you have been describing regarding the Physical Habitat Claims reviewed by a third party?

Yes. Much earlier in this adjudication process, at OWRD's request, information was provided to OWRD regarding the BIA's work that encompassed studies commencing in 1990 and extending through June 1999. OWRD transmitted the BIA's information and data related to the BIA Physical Habitat Claims to Dr. Tim Hardin of Hardin-Davis, Inc. OWRD directed Dr. Hardin to complete a "technical review of the adequacy of the data and interpretations related to the BIA instream flow claims" (OWRD Ex. 1, p. 673).

The BIA amended its Physical Habitat Claims in October 1999. In October 1999, Dr. Hardin presented a report of his findings: Analysis of Hydraulic and Habitat Models Supporting BIA Instream Flow Claims in the Klamath River Basin (OWRD Ex. 1, pp. 669-700, plus Appendices pp. 701-810) ("Hardin report"). It is unclear from Dr. Hardin's report whether he was able to review the BIA's amended 1999 Physical Habitat Claims and I assume that he did not. Nonetheless, the focus of Dr. Hardin's report was on the information and data provided by the BIA through June 1999 which formed the basis of the amended 1999 Physical Habitat Claims.

231. Are you familiar with Dr. Hardin and whether he is qualified to complete a review as requested by OWRD?

I consider Dr. Hardin qualified to complete a technical review of PHABSIM-type data. I understand that he has been involved in conducting instream flow studies for many years, primarily as a private consultant working for Hardin-Davis, Inc.

232. What was the nature of the Hardin report?

I understand that Dr. Hardin was retained by OWRD to review the BIA instream flow data to help OWRD better understand the basis for the BIA's instream flow claims. Dr. Hardin was asked for his opinion as to the adequacy of the underlying data, the data collection methods, and the data analyses. The review focused on four key questions (OWRD Ex. 1, pp. 674-675):

a. Was the Physical Habitat Simulation model (PHABSIM) the appropriate model for the study? (OWRD Ex. 1, p. 674)
b. Were elements of the study designed well? (OWRD Ex. 1, p. 674)
c. Were hydraulic data collection and processing carried out correctly? (OWRD Ex. 1, p. 674) and
d. Was the HABITAT model applied correctly? (OWRD Ex. 1, p. 675)

233. What were the findings of the Hardin report?

In general, the findings served to identify both strengths and potential weaknesses in BIA's approach, the level of data collection, and the analyses that had been completed by the time of Dr. Hardin's 1999 review.

234. Please explain generally the conclusions of the Hardin report related to each of the four questions noted above, starting with the first question - was PHABSIM the appropriate model for the study?

Dr. Hardin acknowledged that other methods are available and specifically cited some of those I have described in Section IV of my testimony, including the Tennant Method and Oregon Method. Dr. Hardin concluded that "PHABSIM was an acceptable method to use in quantifying fish habitat potential as a function of flow" (OWRD Ex. 1, p. 676).

235. Did you take any steps or measures as a result of the report's conclusion related to the PHABSIM model?

Generally, yes. We continued to apply IFIM/PHABSIM in developing the Physical Habitat Claims on as many streams as possible, and only resorted to another method, the Tennant Method, when access restrictions precluded collection of field data. As part of this, we added a number of new study sites beyond those reviewed by Dr. Hardin, from which IFIM/PHABSIM data were collected and analyzed. These additional sites were added, in part, to address some of the other technical concerns noted by Dr. Hardin, presented below, and to refine the Physical Habitat Claims presented in my testimony today.

236. What did the Hardin report conclude regarding the second question – were elements of the study well designed?

Dr. Hardin proffered five separate conclusions corresponding to six separate elements (streamflow records, channel equilibrium, water quality, priority species and lifestages, selection of sites and transects, and habitat suitability curves) that he considered in addressing the question.

237. What was the report's conclusion regarding the first element of the second question – streamflow records?

Dr. Hardin concluded that "[t]he BIA claims need more hydrological context. Monthly claims should, at a minimum be compared to the natural 50% exceedence flows" (OWRD Ex. 1, p. 677).

238. Please describe generally any steps or measures taken to address the report's conclusion related to the first element - streamflow records.

For element 1- streamflow records, we completed a number of steps subsequent to the Hardin report that focused on hydrology. This included a more thorough review of available hydrology data for streams in the Upper Klamath Basin including, in particular, the OWRD hydrology as described in Cooper (2004), which was not available in 1999. In addition, we also collected additional years of streamflow data that were used in evaluating the Cooper (2004) hydrology. The overall process we used for applying the hydrology data to the Physical Habitat Claim derivation process is described more thoroughly in Mr. Ramey Direct Testimony. Of note, we are now specifically using the 50% exceedence flow statistic mentioned by Dr. Hardin (termed "median flow" throughout my testimony), as the hydrologic limit of the Physical Habitat Claims.

239. What was the report's conclusion regarding the second element of the second question - channel equilibrium; and the third element - water quality?

Dr. Hardin combined both the second element - channel equilibrium - and the third element - water quality - into a single conclusion. Dr. Hardin concluded:

> Some of the study streams are seriously degraded by overgrazing. This decreases bank stability, shade and cover to a great extent. Flow restoration alone will have limited fishery benefits unless grazing and other land use issues are also addressed. This does not mean that the BIA focus on flows is invalid; it means that flows are only part of the equation.
>
> (OWRD Ex. 1, p. 677).

240. What steps or measures were taken or additional studies completed to address the report's conclusions related to the second and third elements?

I generally agree with Dr. Hardin's conclusion that flow is not the only component of a healthy and productive fish habitat. Grazing and other land use practices have a significant impact on fish habitat. I described this and, generally, the current conditions of the subbasin in Section VI of my testimony (questions 123 through 129). Related to water quality, we considered dissolved oxygen as a factor affecting fish habitat (see generally Section IV, question 86). In addition, to the extent that information and data were available, we completed and considered water temperature information as provided in the FLIR imaging when establishing Physical Habitat flow values in each claim reach (see generally Section IV, questions 95 through 97). However, as recognized by Dr. Hardin, sufficient streamflows are a critical ingredient in the development and sustainability of a fishery. In addition, quantifying streamflow is the only focus of the Adjudication. Thus, we focused on determining the amount of flow necessary in the claims work.

241. What was the report's conclusion regarding the fourth element of the second question – priority species and life stages?

Dr. Hardin's overall conclusion was that "[t]he BIA claims are almost entirely based on WUA results for rainbow trout. This simplifies the analyses but may be hard to justify ecologically" (OWRD Ex. 1, p. 678).

242. What steps or measures were taken or additional studies completed to address the report's conclusions related to element 4 – priority species and life stages?

None explicitly; however, at the time of his review, Dr. Hardin was not aware of two components of the basis and rationale for developing the claims. First, Dr. Hardin was not aware of the lifestage prioritization we used in developing the claims that resulted in lifestage rankings: spawning (first priority), adult (second priority), juvenile (third priority), and fry (fourth priority). Second, Dr. Hardin was not aware of the species prioritization we used in developing the claims that resulted in species rankings: redband trout (first priority species); Lost River sucker (second priority species); shortnose sucker (third priority species); Klamath largescale sucker (fourth priority species); and bull trout (fifth priority species). These components were described earlier in this section (see generally Section II question 25 and Section VII questions 166 through 171).

With this information, Dr. Hardin's critique is addressed as to the technical and ecological basis for the claims, and why certain species and lifestage combinations formed the basis for specific monthly claims more frequently than others. In addition, although, as alluded to in the report, there are other approaches to data analysis that could have been used, including "the simultaneous evaluation of a bewildering mix of species and lifestages," (OWRD Ex. 1 p. 678), the results of that type of an analysis are typically difficult to interpret and do not lend themselves to the situation where the prioritization of lifestages and species have been clearly defined.

243. What was the report's conclusion regarding the fifth element of the second question – selection of sites and transects?

With respect to this element, Dr. Hardin concluded in 1999:

> In my opinion, the number of transects used in this study is minimal, and probably insufficient. The use of low numbers of transects has serious implications for the precision of the PHABSIM model. Low numbers of transects mean that the final results may be more of a general indication of the WUA vs. flow relationship, rather than an accurate quantification. Because no rainbow trout spawning transects were placed and the amount of potential spawning habitat is low in many reaches, the WUA figures for rainbow trout spawning are unlikely to be

> reliable for setting flow claims. Rainbow trout spawning should probably be removed as a priority life stage in at least a third of the sites.
>
> (OWRD Ex. 1, p. 679).

244. What steps or measures were taken or additional studies completed to address the report's conclusions related to element 5 – selection of sites and transects?

With respect to the critique related to the number and types of sites and transects selected, we engaged in a comprehensive review of the transects we relied upon. Since the Hardin report, we have collected supplemental data from re-established transects at a number of existing sites; established and collected data from several additional sites and transects including three (3) sites on the lower Sprague River, one (1) site on the lower Williamson River, one (1) site on the South Fork Sprague River, and one (1) site on Whisky Creek; and completely re-analyzed the existing data used in the 1999 amended claims development process.

The above efforts have substantially increased the overall numbers of transects from which PHABSIM data have been collected, analyzed, and applied in developing the Physical Habitat Claims presented in my testimony today. In addition, for those areas in which we did not establish new or gather additional transect data, our further analysis confirmed that given the uniformity of stream habitat types (pool, riffle, run, etc.) and channel characteristics, additional transect data were not necessary.

Further, several of the new transects were purposely located across known sucker and redband trout spawning areas. In addition, we developed an additional step (see Section VIII, question 260, Final Step Four) as part of the flow derivation process that specifically considered the amount of spawning habitat available under different flows for a given site. Under that step, if the amount of spawning habitat available at a specific site was determined to be below a threshold amount, then consideration was given to shifting the basis for the claim to the next priority life stage/species.

245. What was the report's conclusion regarding the sixth element of the second question – habitat suitability curves?

Overall, Dr. Hardin concluded:

> [t]he depth and velocity curves are probably acceptable for most of the priority life stages. New data should be reviewed if possible, for bull trout, and winter rainbow trout, these curves may need to be adjusted. Binary aspects of the rainbow trout spawning curves should be changed, if this life stage is to remain a priority. The models appear to be overly general for rainbow trout. The decision not to include cover reduces the resolution of the study.
>
> (OWRD Ex. 1, p. 680).

246. What steps or measures were taken or additional studies completed to address the report's conclusions related to element 6 – habitat suitability curves?

As described earlier in this section, since 1999 and in part to address Dr. Hardin's observations, we have collected more than 700 redband trout microhabitat use measurements for fry, juvenile, adult and spawning lifestages; 24 bull trout habitat measurements; and 31 Lost River sucker habitat measurements (See Table VII-4). These measurements were used in developing site specific HSC criteria for redband trout spawning and adult life stages, and for updating the previously applied HSC curves to better reflect habitat characteristics actually being used by the target fish species in the Upper Klamath Basin. Our decision not to incorporate cover into the HSC criteria was based on the fact that cover is highly site specific and, therefore, would not be representative of conditions in claim reaches that often encompassed long stretches of stream.

247. Moving next to Dr. Hardin's third question, what did the Hardin Review conclude regarding the third question – were hydraulic data collection and processing carried out correctly?

Dr. Hardin's review and conclusions relative to the collection and analysis of hydraulic data centered on the quality of the data and resulting model output used in deriving the 1999 amended claims.

248. What steps or measures were taken or additional studies completed to address the report's conclusions related to hydraulic data collection and processing?

As to each of the hydraulic data issues identified in the Hardin report, each was given additional, careful consideration, and each was addressed as part of the comprehensive evaluation I just described of all data and model calibration details used in the development of the amended 1999 Physical Habitat Claims. As a result of our comprehensive review, model recalibrations were made on a number of the sites, supplemental field measurements were collected from existing sites and used in model calibrations, and several new sites were established from which new data sets were collected and used in model development. These efforts served to refine and supplement the data that had been collected to support the 1999 amended claims. Overall, these efforts increased the reliability of the data and model results that were used in deriving the Physical Habitat Claims presented in this testimony.

249. What did the Hardin report conclude regarding the fourth and final question – was the HABTAT model applied correctly?

Dr. Hardin provided comments relative to four categories under the final question: (1) site-by-site WUA; (2) level of confidence in the final WUA curves; (3) interpretation of WUA to obtain flow claims; and (4) other issues in WUA interpretation.

250. What steps or measures were taken or additional studies completed to address the report's conclusions related to WUA?

The first category - site-by-site WUA - was simply a check of the data output of the WUA models which Dr. Hardin confirmed were correct. The second category - level of confidence in the final WUA curves - pertained to the data issues described above. As I described, these issues were resolved by the subsequent review of data, recalibration of data sets, re-sampling of certain sites, and establishment and measurement of new sites and additional transects.

For the third category - interpretation of WUA to obtain flow claims - Dr. Hardin concluded:

> [t]he BIA calculations of WUA per site are consistent with the input data. Flow recommendations did take into account values other than peak WUA. However, considerable uncertainty remains in the final WUA figures due to low numbers of transects, field data problems, and over-extrapolation of the hydraulic models.
>
> (OWRD Ex. 1, p. 685).

The uncertainty in the final WUA figures noted by Dr. Harding was, again, related to data collection and analysis concerns which have been addressed as described above.

The fourth category - other issues in WUA interpretation - was directed toward consideration of flow-versus-habitat and flow-versus-fish population relationships. I discuss the conceptual differences between these relationships in Sections III and IV. There, I point out that it is generally difficult to demonstrate a direct relationship between flow and numbers of fish because of the many factors that serve to influence population abundance. Further, no recognized methodology exists, as a predictive tool, to establish a flow-versus-fish population direct relationship throughout a river basin environment. For these reasons, we applied an accepted method (the IFIM/PHABSIM method) that focused on habitat–versus-flow relationships

251. Were there any other comments proffered by Dr. Hardin that you considered?

Yes. Dr. Hardin also discussed the extent to which a change in habitat (WUA) could have a notable effect on the fishery. He noted the variability of possible effects on the fishery, "a 5% change in WUA could be significant in some instances, while a 25% change could have no effect in others" (OWRD Ex. 1, p.686). He further concluded that "it is useful to look at the whole range of WUA values, as opposed to just the peak value. In particular, the flows providing 90% or more of peak WUA should be taken into consideration in formulating flow recommendations" (OWRD Ex. 1, p.686).

I generally agree with the points raised by Dr. Hardin here. Further, our evaluation of the WUA curves considered the full range of values, and specifically those providing 90% or more of the peak WUA (see Section VIII, question 260, Final Step Three).

252. Please summarize your overall response to the Hardin report's conclusions.

In general, I found Dr. Hardin's review to be objectively based on the information that had been provided OWRD in June 1999. Dr. Hardin's review was useful in helping to identify specific elements of the overall approach used to derive the 1999 amended Physical Habitat claims that warranted additional consideration. Indeed, subsequent to receipt of the Hardin report, we completed a thorough review of all of the IFIM/PHABSIM data collected. As a result, we completed additional analyses, gathered additional data, and conducted a number of supplemental studies which addressed Dr. Hardin's concerns or conclusions and our own assessments.

VIII. INFORMATION ASSEMBLED AND SPECIFIC ACTIONS TAKEN TO ARRIVE AT THE FINAL UPDATED PHYSICAL HABITAT CLAIMS.

253. Dr. Reiser, please briefly describe your actions to finalize the updating of the Physical Habitat Claims.

The updated Physical Habitat Claims presented in my testimony are the result of the following substantial actions: an extensive review of the pre-1999 data; recalibration of hydraulic models; establishment of and data collection from several new (post-1999) IFIM/PHABSIM study sites; adjustment of HSC curves; additional (post-1999) development of habitat:flow relationships; additional (post-1999) hydrologic information provided by OWRD; review of recent data on species lifestage utilization of Wood River subbasin streams; and the completion of ongoing technical analyses that have both confirmed and refined (downward) the Physical Habitat Claims. The objective consistently throughout this lengthy process was to gather and use the best available scientific information from which to base the Physical Habitat Claims.

I have already described the general methodology applied and steps or procedures followed which formed the basis for the Physical Habitat Claims. Therefore, I will now describe the detailed processes used for updating the Physical Habitat flow values necessary for each claim reach and each claim month.

254. Please describe whether consideration of anadromous fish species, and specifically Chinook salmon impacted the specific steps you took to arrive at the final Physical Habitat Claims.

As discussed earlier, the current absence of but the likely future presence of anadromous fish species, and particularly Chinook salmon, has caused a refinement to the 1999 Physical Habitat Claims. The Physical Habitat Claims are now divided into sub-parts: Physical Habitat

Claims based on *present* target fish species, and *conditional* Physical Habitat Claims based on *all* target fish species, including the anadromous Chinook salmon.

255. Please describe what you mean by *present* target fish species and what you mean by *all* target fish species.

As I have already described in Section VII of my testimony, the target fish species which were the focus of our work and the Physical Habitat Claims included Chinook salmon, bull trout, redband trout, Lost River sucker, shortnose sucker, and Klamath largescale sucker. These six species constitute *all* target fish species.

Present target fish species include those five target fish species that currently reside in the streams of the Upper Klamath Basin, i.e., bull trout, redband trout, Lost River sucker, shortnose sucker; and Klamath largescale sucker. Return of Chinook salmon and other anadromous species to the area of the Upper Klamath River Basin is reasonably possible under a number of scenarios (FERC 2006; Hooton and Smith 2008). When the anadromous fish return, they are likely to return to those habitats that they once occupied so long as the fish habitat is of sufficient quality (i.e., healthy) to support its relevant lifestages. They will also likely discover and utilize new habitats to support their lifestages.

As I have described, the habitat:flow relationships analyzed and calculated to ultimately determine the flows necessary to ensure no more than a healthy and productive habitat turn, in part, on the fish species considered. Though the process and steps to determine an appropriate habitat:flow relationship remain the same, with the needs of an additional fish species taken into consideration the opportunity arises for different flow recommendations to result.

256. Please describe what you mean by *conditional* Physical Habitat Claims.

To the same extent that I have gathered data and applied an established methodology to form the basis to make Physical Habitat Claims for target fish species that currently reside in the streams of the Upper Klamath River Basin, I have gathered sufficient data and applied the same methodology to form the basis to make Physical Habitat Claims for *all* target fish species, including Chinook salmon. The notion of *conditional* Physical Habitat Claims takes into account the probable return of anadromous species, including the Chinook salmon, to the Upper Klamath River Basin. These *conditional* Physical Habitat Claims should be followed when anadromous fish are reintroduced to the Upper Klamath Basin.

257. Please describe the Physical Habitat Claims which are based on *present* target fish species and how they are distinct from *conditional* Physical Habitat Claims.

In the simplest of terms, those Physical Habitat Claims that I have determined to be necessary for *present* target fish species are those flows necessary *today,* to provide for the physical habitat of fish. These flows establish that amount of flow necessary to provide a healthy and productive habitat for the target fish species currently living in the upper Klamath River Basin generally and the Wood River subbasin specifically. The present Physical Habitat flow claims do not take into consideration the needs of Chinook salmon or any other anadromous species.

The Physical Habitat Claims that I describe as *conditional* are those flows that I have determined will be needed in the future when anadromous fish are permitted to return to the Upper Klamath Basin. These flows establish that amount of flow necessary to provide a healthy and productive habitat for *all* target fish species, including Chinook salmon. These *conditional* Physical Habitat Claims were established by considering all six target fish species.

258. Are the updated Physical Habitat Claims that you describe today, whether *conditional* or not, greater than those values claimed through the 1999 Physical Habitat Claims?

No. In every instance, whether for present target species or for all target species, the Physical Habitat Claims are *at or below and certainly no more than* the Physical Habitat flows claimed in 1999. Further, the Physical Habitat Claims today are refined into two components: a component based on *present* target species in the Upper Klamath Basin and a conditional component based on the *future likely return* of the important anadromous target fish species, Chinook salmon. By refining the Physical Habitat Claim into current and conditional claims, we are assured that no more than the water necessary to provide healthy and productive habitat for fish is claimed.

259. Please describe the specific information that you assembled to form the final basis for the Physical Habitat Claims in the Wood River subbasin for each calendar month.

With all field data gathered and reduced and all computer analysis and modeling performed, a logical sequence of decisions was developed to account for all relevant information and to base my final recommendation for a specific claim reach and a specific month. Also, as the Physical Habitat Claims for present species and all species (i.e., present and *conditional* Physical Habitat Claims) involved the same final decision-making process, the materials and information assembled for both were virtually identical.

Immediately below, I briefly describe the information specifically assembled to arrive at the Physical Habitat Claims, and the source that was generally relied upon for the information.

- **Target fish species presence, lifestage use, and periodicity (including historic distribution):**

Though possibly present in the greater Wood River subbasin, not all target fish species were or should be considered present in each claim reach. Therefore, species, lifestage and periodicity for each reach needed to be specifically identified. This information was obtained from a variety of sources that included the Klamath Tribes, ODFW, USFWS, USGS, and USFS. Further details regarding the identification of target fish species, and lifestage periodicities are provided in Sections II and VII.

- **Prioritization of lifestage and target fish species (primary, secondary, tertiary):**

For the lifestages, species, and periodicity identified, the information was assembled based on developed priorities. Further details regarding the establishment of lifestage and species priorities are provided in Section VII.

- **Identification of claim reaches that support federally protected species and/or with special habitat characteristics and conditions (e.g., spring dominated, critical spawning habitat, upstream passage corridor):**

Here, reach-specific information related to the presence of ESA-listed species and any special conditions (e.g., water quality, critical spawning, adult passage conditions, etc.) was obtained primarily from the USFWS or the ODFW. In addition, identification of special characteristics and conditions within a given reach was based on information obtained during our review of literature, results of extensive field surveys conducted over the previous two decades, and discussions with the resource agency and the Klamath Tribes. For example, there are a number of spring-dominated streams in the Upper Klamath Basin that are characterized by stable flow and stable temperature conditions. The influence of these conditions extends well below a given reach. Likewise, certain claim reaches serve as the main passage corridors through which adult adfluvial target fish species (e.g., redband trout, Lost River sucker, shortnose sucker, Klamath largescale sucker and Chinook salmon (when reintroduced)) must migrate through in order to reach spawning and rearing habitats. As fish habitats and fish use have developed around these unique characteristics and conditions, this information needed to be considered in the development of the Physical Habitat Claims.

- **Habitat:flow relationship curves:**

The habitat:flow relationship (WUA-Q) values and curves generated for various lifestages and target fish species were the primary outputs from the IFIM/PHABSIM modeling. These values and curves were the primary basis on which many Physical Habitat Claims were made.

- **Monthly median flow:**

The monthly median flow represents flow that for a given stream and month that would be exceeded half of the time based on hydrological records. The specific median flow estimates used in my analysis were those established by OWRD as described in Mr. Ramey Direct Testimony at question 47. As described in Section VII and based on a conservative determination of the threshold needs provide a healthy and productive habitat, this flow statistic represented a hydrologic limit of the Physical Habitat Claims for all reaches and all months and ensures connection between the hydrology of the Upper Klamath Basin and the IFIM/PHABSIM based flow values. No Physical Habitat flows for any claim reach or any calendar month exceeded OWRD's median flow estimates.

- **1999 Physical Habitat flow claims:**

As described in Section VII, the 1999 Physical Habitat Claims formed the final consideration of the claims analysis and a second upper boundary of the updated Physical Habitat Claims for both *present* and conditional claims. Similar to the median flow limit, no updated Physical Habitat Claim for any claim reach or any calendar month, exceeded the 1999 Physical Habitat Claim values.

260. Please describe the final process by which you determined the final updated Physical Habitat Claims in the Wood River subbasin.

I assembled the above information in updating the Physical Habitat Claims for each month and for each claim (Claims 668 through 670). I then reviewed the assembled information to ensure accuracy and completeness. With the assembled information, I applied the information in a decision process to develop specific monthly flow recommendations for each claim reach. It was in this review process that I considered those principles and factors described by Naiman and Latterell (Naiman and Latterell 2005) and the Instream Flow Council (Annear et al. 2004; Locke et al. 2008) (see Section IV).

Below, I describe the eight specific steps of the final decision process followed to ultimately arrive at the final updated Physical Habitat Claims for each claim reach and each calendar month.

- **Final Step One – Derivation and Review of habitat:flow relationship (WUA-Q) values:**

Broadly speaking, the WUA provides the best indication of the "livable area" that a stream provides a given species lifestage at a given instream flow. After establishing the habitat:flow relationships over a range of flows, the flow levels that provided optimal WUA or the greatest livable area for each month's priority were identified. The resulting flow was recorded based on priority species, lifestage, claim reach use, and/or sensitivity of or value to listed species. Flows providing 90 percent and 80 percent of the optimum habitats were likewise computed.

- **Final Step Two – Application of habitat:flow relationship (WUA-Q) values for claim reaches containing unique characteristics or critical habitat features:**

We then determined whether the claim reach should be considered "unique." First, we questioned whether the claim reach served a critical role (e.g., temperature, water quality, critical spawning, adult passage, etc.) in supporting target fish species habitat characteristics within the reach, and whether the conditions critically influenced downstream claim reaches. If the answer was yes, we then focused on selecting the flows that would allow for the full range of habitats to occur (i.e., provide the greatest amount of livable space for the priority lifestage and species).

In the Wood River subbasin there were three claims (Claim 668, Claim 669, and Claim 670) that because of their ecological significance to other reaches and their overall importance in supporting target fish species I considered unique. For those claims, the Physical Habitat Claims focused on providing flows that would allow for the full range of habitats of the priority lifestage and species to occur, as governed by the conditions imposed by final steps three through eight described below. The rationale for the designation of each of these claims as unique is found in Section IX under the specific claim number.

- **Final Step Three – Application of habitat:flow relationship (WUA-Q) values for claim reaches that do not contain unique characteristics or critical habitat features:**

For claim reaches not containing unique characteristics or critical habitats, the habitat:flow relationship curves for the priority lifestage and target fish species were carefully reviewed in terms of their shapes and the flows providing habitat amounts at different levels (100%, 90%, and 80%) on the curves. A broad review of all curves for all claim reaches suggested that the gains in habitat that would occur as a result of the selection of the flow that would have provided the full range of habitat values (i.e., 100%) would not have, in my opinion, substantively increased the amount of productive habitat. In contrast, I believed that decreasing the flow level to that providing 80 percent of the full range of habitat would not have allowed for the long term sustainability of healthy and productive habitats. Therefore, I selected the 90 percent WUA value as the primary basis for selecting a flow value (subject to the hydrologic and 1999 claim limitations noted below). I believe this value would provide for no more than a healthy and productive habitat.

- **Final Step Four – available spawning habitat:**

Sufficient spawning area is necessary for creation of spawning redds for resident, adfluvial, and anadromous salmonids. For spawning priority months, if the recommended flow resulted in <1,000 square feet per thousand feet of spawning habitat for adfluvial or anadromous species or <500 square feet per thousand feet for resident trout species, the claim reach was flagged for further individual review. Using the average stream width, the total available square feet of spawning habitat in 1,000 feet of the stream was calculated. If the updated claim resulted in spawning area comprising less than 10 percent of the total area, then we considered increasing the flow to provide additional spawning area. If additional flow would not increase the amount of spawning habitat, consideration was given to shift the basis of the claim to the next priority lifestage.

- **Final Step Five – egg incubation flow:**

For each month following a spawning priority month that was within the incubation period, the incubation flow was two-thirds the recommended spawning flow level. Two-thirds of the spawning flow is considered necessary to protect eggs from dewatering, freezing, and inadequate water quality (Thompson 1972). The incubation flow operated as a "shadow" to the spawning lifestage and thus was only invoked in those post-spawning, incubation months if the necessary flow for the priority lifestage was less than the incubation flow. For those months, the updated flow claim was based on the incubation flow.

- **Final Step Six – consideration of whether the flow compromised other species or lifestages:**

To ensure that the derived flow would not benefit habitat conditions for one species or lifestage at the expense of another, we reviewed the habitat:flow relationships of other species and lifestages. This review focused on evaluating the amounts of habitat that would be provided for the other species and lifestages by the flow amount for the priority lifestage and species.

- **Final Step Seven – Median flow limit:**

We then compared the habitat:flow based flow derived from Steps 3 through 6 above with the median flow values, and the flow value became the lower of the two. The median flow limit provides an upper limit to the Physical Habitat Claims that is well below any notion of a "wilderness servitude" and is within the realistic boundaries of what the hydrologic conditions of the subbasin provides. Further, it is reasonably assumed that the median flow will meet the necessary basic flow requirements of target fish species and provide no more than sufficient flow to provide and maintain healthy and productive fish habitat.

- **Final Step Eight – 1999 Physical Habitat Claim limit:**

As a final step, we compared the flow derived from Steps 3 through 7, above, with the 1999 Physical Habitat Claim value. The updated Physical Habitat Claim became the lower of the two. Therefore, in those instances where the 1999 Physical Habitat Claim was less than the PHABSIM-based flow and the median flow, the 1999 Physical Habitat flow claims became the basis for the monthly Physical Habitat Claim.

261. Was the final eight-step claim update process applied to Physical Habitat Claims for present target fish species and for conditional Physical Habitat Claims for all target fish species?

Yes. For the purposes of the final claim update process described above, the only distinction between the Physical Habitat Claims based on present species and all species is the number of species considered, five species and six species, respectively. For the purpose of establishing the conditional Physical Habitat Claims, the final eight steps were followed a second time with Chinook salmon included as a possible priority species. Any change in Physical Habitat Claims in the second application of the decision steps resulted in a conditional Physical Habitat flow, only to be given effect in the event Chinook salmon are reintroduced in the Upper Klamath Basin. If the second application of the decision steps resulted in no change to the Physical Habitat Claim, no conditional claim was made.

262. By applying these final steps that you have described above what were you able to achieve?

The uniform final process described above and applied to each claim reach in the Wood River subbasin (for each calendar month) provides several benefits. First, these processes allowed me to assemble, sort, and apply a vast amount of data and information to prepare and support the basis for my conclusions. Second, by establishing and engaging in these processes in advance, that the information necessary to update the Physical Habitat Claims was consistently and uniformly considered in my analysis. Finally, each applicable factor was given appropriate consideration.

IX. THE WOOD RIVER PHYSICAL HABITAT CLAIMS

263. How many Physical Habitat Claims are there for the Wood River subbasin?

There is a total of three separate claims for the Wood River subbasin, consisting of one claim (Claim 668) for the mainstem Wood River, and two claims (Claim 669 – Crooked Creek; and Claim 670 – Fort Creek) for individual tributaries to the river.

264. In what order will you present and discuss the individual Physical Habitat Claims?

I will discuss the individual Physical Habitat Claims in numerical order, beginning with Claim 668 and ending with Claim 670. For each of the Physical Habitat Claims, I will first describe the reach of the stream encompassed by each claim (e.g., general characteristics such as, length and location of the reach, and stream hydrology). To aid in this, I have included a map depicting the location of each claim, and a hydrograph showing the monthly median flows for the reach, as determined by Cooper (2004). I will then describe other salient information about the claim reach including my familiarity with the reach; the stream environment (such as, the channel composition, substrate, and vegetation); the target fish species that are or were historically present in the claim reach; and the field data collected and used to develop habitat: flow relationships for the claim reach. This is followed by a description of the flow quantities and the rationale for each individual updated Physical Habitat Claim, including the updated current and conditional monthly claim flow values. As discussed in Section VII, the "current" Physical Habitat Claims reflect the flows necessary for the target fish species that currently exist in the Upper Klamath Basin, and the "conditional" Physical Habitat Claims reflect the flows that are necessary for, and which would be applied subsequent to the reintroduction of anadromous fish to the claim reach.

265. Prior to discussing each individual claim, please describe generally the basis and technical rationale that you applied to develop each updated Physical Habitat Claim.

The basis and technical rationale for each updated Physical Habitat Claim and its monthly flow values included the following primary determinants: the lifestage/species priority for each month; incubation flows in months following spawning; the median monthly flow, which represents the hydrologic limit to the Physical Habitat Claim; and the 1999 monthly flow value, which represents the overall upper limit to the Physical Habitat Claim. Consideration of each of these determinants provided the specified flow value for each month. The general basis and technical rationale for the Physical Habitat Claims' monthly flow values are further described in Sections VII and VIII.

As to the conditional Physical Habitat monthly flow values, the same determinants as noted above provided the rational for the conditional flow values, with the only difference being that in certain months a different species prioritization applied. In other words, for streams or stream reaches in which Chinook salmon was historically present and for which there would be a biological likelihood of presence if reintroduced, Chinook salmon were included as a target species. For each reach in which a conditional claim applies, I have provided a separate discussion that describes the rationale involved in selecting each of the conditional flow values.

CLAIM 668 – WOOD RIVER: ANNIE CREEK TO AGENCY LAKE

266. Please describe the stream reach associated with Claim 668.

Claim 668 encompasses the reach of the Wood River extending from Agency Lake upstream approximately 16.0 miles to the confluence with Annie Creek (hereinafter called "Claim Reach 668"). See OWRD Ex. 46 at 16 describing the upper and lower boundaries of the Claim Reach; also see Figure IX-668-1 and Figure IX-668-2.

The Wood River within Claim Reach 668 has a low stream gradient (0.1 to 0.2%) and possesses a meandering, unconfined channel averaging approximately 52 feet wide (Ex. 281-US-416, Ex. 281-US-417). The river valley in this reach can be characterized as a wide floodplain with gently rolling slopes (Ex. 281-US-416). Peak median flow (533 cfs) in the reach typically occurs in June and the low median flow (389 cfs) occurs in late winter (Figure IX-668-3). The lower portion of the claim reach includes the Wood River delta, an area that has been highly modified by agricultural activities and has recently been the focus of a large-scale restoration and enhancement program (Ex. 281-US-418; KBRT 2003).

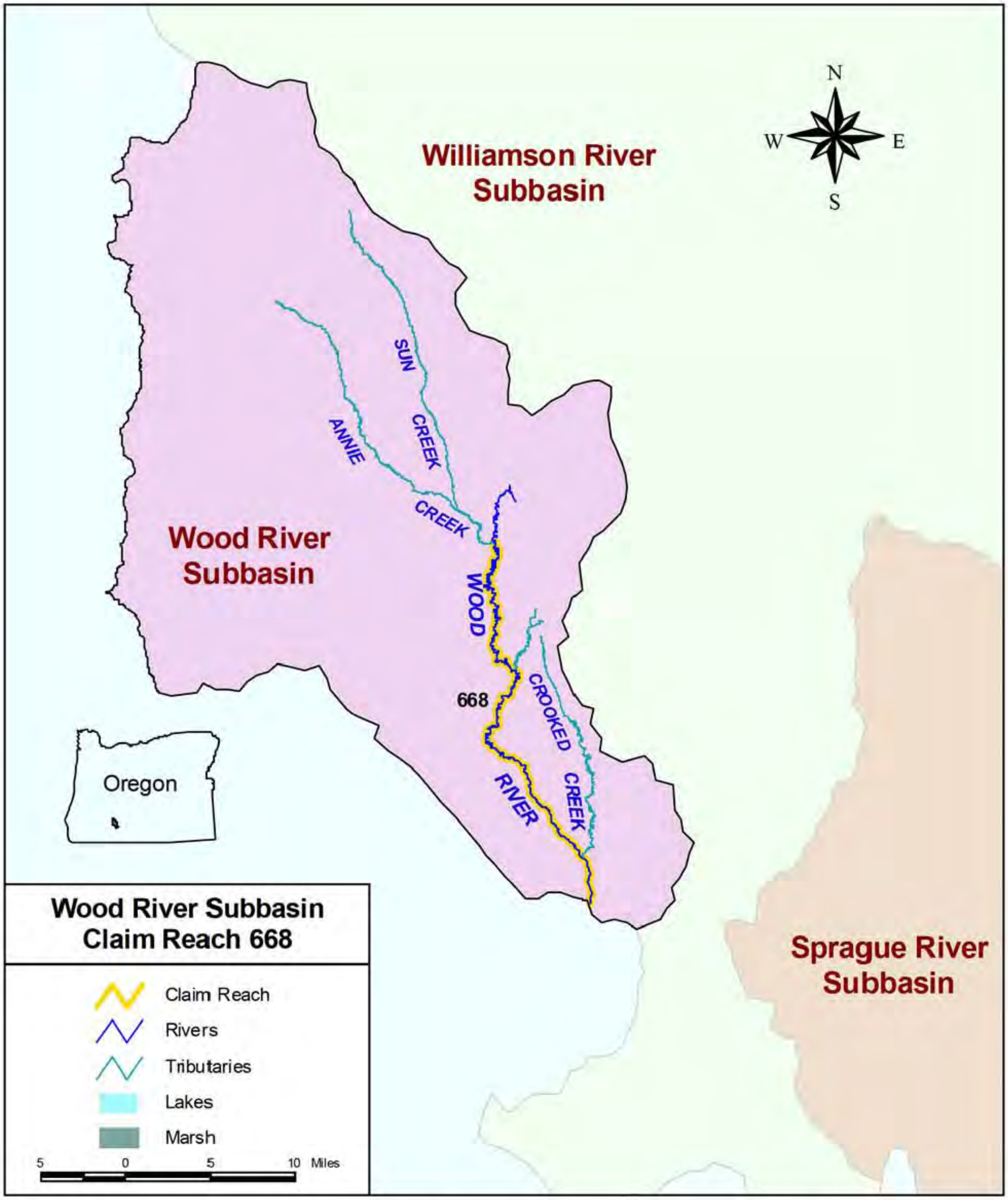

Figure IX-668-1. Claim Reach 688. Wood River subbasin with claim reach highlighted in yellow.

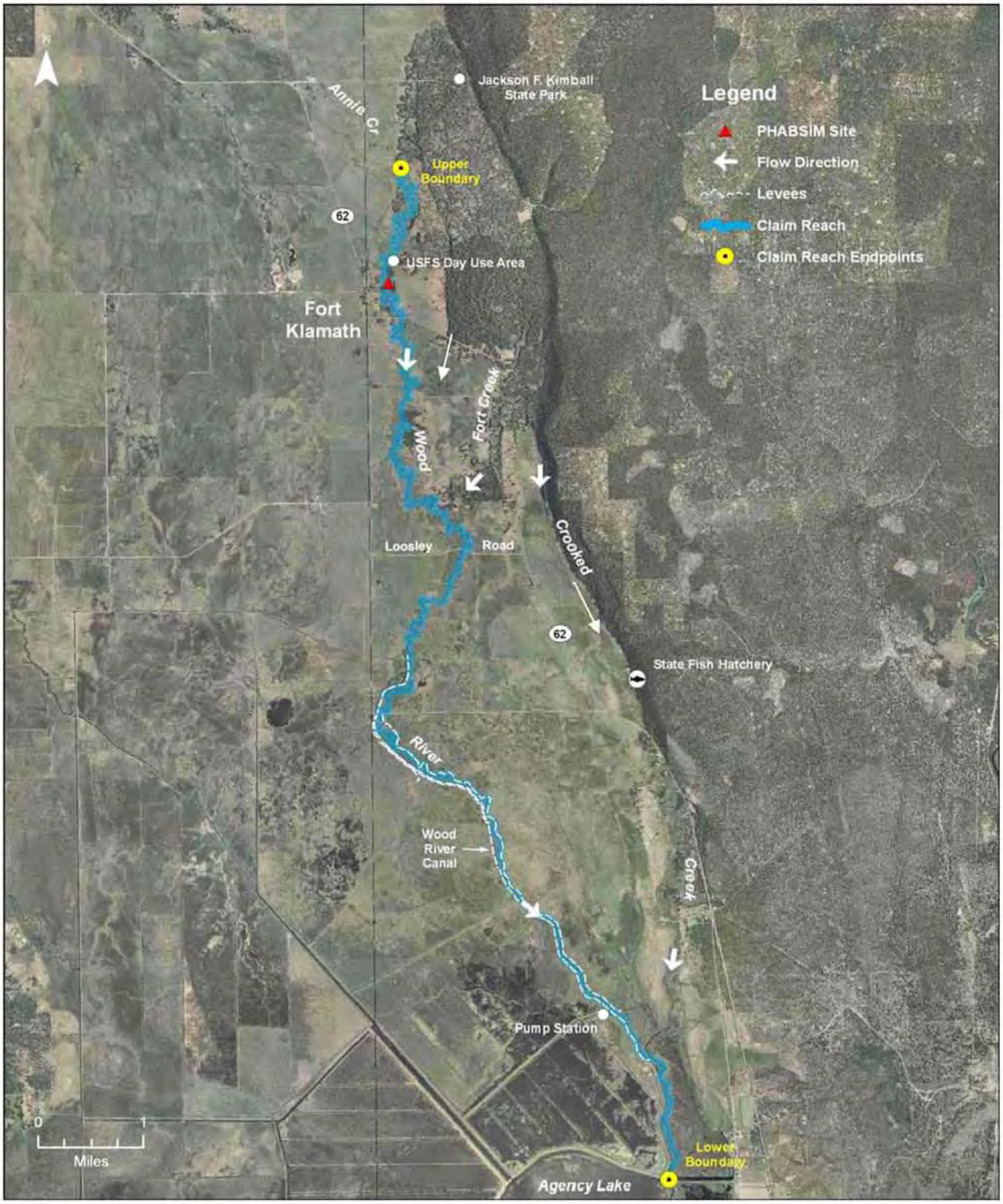

Figure IX-668-2. Orthographic photograph of Claim Reach 668 (Oregon Imagery Explorer 2007).

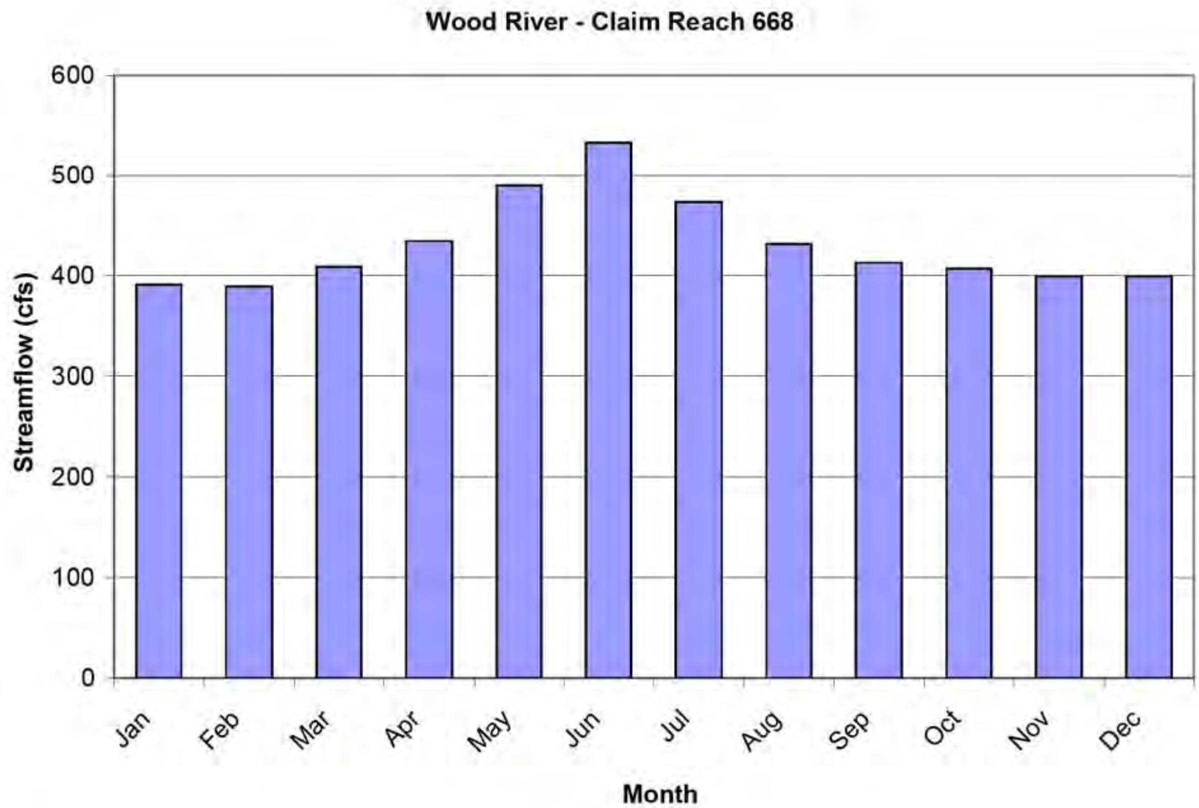

Figure IX-668-3. Wood River monthly hydrograph (median flow values) at high water confluence with Agency Lake (Claim Reach 668) (Cooper 2004).

267. Are you familiar with this reach of the Wood River that comprises Claim Reach 668?

Yes. I have visited several portions of Claim Reach 688 multiple times over the past 20 years including near the Loosley Road crossing and the Highway 62 crossing at Fort Klamath, Oregon. I have also participated in snorkel and redd surveys as part of HSC data collection activities within a reach of the Wood River extending from the upper extent of the claim reach near the headwaters springs near Jackson F. Kimball State Park, downstream for a distance of approximately three miles to the USFS Day Use Area. I have also visited and inspected the detailed study site located at the USFS Day Use Area (Figure IX-688-2). In addition, I participated in the collection of invertebrate samples within the study site. Most recently, I completed a field reconnaissance of the detailed IFIM/PHABSIM site in June 2006 to check transect locations and survey points and assess overall habitat conditions. I have also flown over and photographed from the air the entire length of Claim Reach 668.

268. Please describe the stream environment associated with Claim Reach 668.

Based on my observations and information from other sources, the stream environment associated with Claim Reach 668 is as follows. The claim reach flows through a flat valley that is dominated by agricultural land use, primarily pasture land. The riparian vegetation is dominated by sedges, rushes, and grasses, and scattered stands of willow and aspen exist along the stream channel. In some areas, the riparian vegetation is marsh like. Where grazing has been excluded, willow cover is much higher, thicker, and more diverse. Willow cover throughout the area was likely much higher and encompassing along the river prior to the introduction of cattle to the area in the late 19th century. Grazing has impacted much of the riparian vegetation. In a 2004 ODFW aquatic survey, willow stands were noted to be dominated by old plants, indicating little reproduction by either seed or root sprouting (Ex. 281-US-418).

With respect to fish habitat, the upper half of Claim Reach 668, extending from the confluence with Annie Creek downstream approximately 8.0 miles to the confluence with Fort Creek, has a low gradient consisting primarily of glide habitat with some pools and riffles (Ex. 281-US-418). Most of the pool habitats are located at meander bends; multiple dikes and levees have reduced the ability of the river to meander. Most of the riffle habitats are located just below the confluence with Annie Creek. Substrates suitable for spawning at low flow are present and are located in riffle areas. Visual estimates made by ODFW (Ex. 281-US-418) indicated a total of 36,770 square feet of gravel present within the reach that would be suitable for salmonid spawning. The streambed in the glide and pool habitats within the upper portion of the Claim Reach is generally dominated by fine substrates consisting of sands and organics (Ex. 281-US-419).

The lower half of Claim Reach 668, extending from the confluence with Fort Creek downstream approximately 8.0 miles to Agency Lake, has been extensively channelized due to agricultural activities and consists primarily of glide habitat with occasional scour holes (Ex. 281-US-418). The channelization of the lower portion has resulted in the loss of riparian vegetation and has been linked to lower survival rates of endangered suckers (USFWS 1993; White et al. 1995). The streambed within this lower portion of the Claim Reach is dominated by fine substrates consisting of sands and organics. Some pumice gravel was noted below Fort Creek, but no substrate was judged suitable for spawning anywhere in the lower half of the Claim Reach 668 (Ex. 281-US-418).

269. Please describe the target fish species that currently, and in the future will, utilize this reach.

The target fish species that currently occur in this reach include redband trout, shortnose sucker, Lost River sucker, and Klamath largescale sucker. Claim Reach 668 provides a migratory corridor for adfluvial redband trout and shortnose, Lost River, and Klamath largescale suckers moving from Agency Lake to spawning areas in upstream tributaries of the Wood River subbasin (Claim Reach 669 and 670), and for downstream migrating post-spawning fish, larval fish, and juvenile fish (White et al. 1995). Redband trout and sucker spawning habitats are limited to the riffle areas located in the upper portion of Claim Reach 668. Undercut banks in the upper portion of the reach provide ample cover for juvenile redband trout rearing (Ex. 281-US-418).

Numerous other fish species that primarily inhabit Agency Lake may also use the lower-most part of the Wood River under certain lake conditions: blue chub, tui chub, speckled dace, and Pit-Klamath brook lamprey (Ex. 281-US-413). Brown trout are also present throughout the claim reach (KBRT 2003). Bull trout are currently present in Sun Creek, a tributary to the Wood River at the upstream end of Claim Reach 668 and are assumed to have historically used this claim reach (Buchanan et al. 1997; USFWS 2002).

Claim Reach 668 will be especially important to Chinook salmon upon reintroduction into the Upper Klamath Basin (Hooton and Smith 2008). In addition to providing spawning habitat within the upper portion of the reach, Claim Reach 668 of the Wood River represents the necessary migration portal for all adult salmon moving into streams to spawn within the Wood River subbasin (Figure VII-6). The claim reach must also provide the necessary downstream migration portal for all Chinook salmon juveniles and smolts that are moving downstream to the ocean.

270. What field data were collected and used to develop the updated Physical Habitat flow values for Claim 668?

The collection of field data for this site followed the general methods and sampling procedures described in Section VII. The detailed sampling site for this reach was established in May 2004 and was based on habitat mapping conducted on a section of the river approximately 2,382 feet long (Figure IX-668-2). Stream habitat diversity was moderate with pool habitat (43.2%) and riffle habitat (56.8%) present (Ex. 281-US-417). A total of six (6) PHABSIM transects were established and sampled during three separate visits. A summary of the data collection is provided in Table IX-668-1 and a photograph of transect two from the sample site is provided in Figure IX-668-3.

The Wood River was one of the streams in which we collected fish habitat utilization data that went into the derivation of site specific HSC criteria (see Section VII). This included the collection of water depth and velocity measurements over redband trout redds (egg nests), as well as measurements of locations occupied by juvenile and adult redband trout.

Table IX-668-1. Dates, habitat types sampled, and number of transects measured during each field survey completed for Claim Reach 668.

Survey Date	Habitat Type(s) Sampled	Number of Transects
05/14/2004	Pool/Riffle	6
06/28/2004	Pool/Riffle	6
08/17/2004	Pool/Riffle	6

Figure IX-668-4. Wood River (Claim Reach 668), IFIM/PHABSIM sample site at Riffle Transect 2, on June 28, 2004.

Ex. 281-US-417 includes copies of the field data collected and used to develop the updated Physical Habitat flow values for Claim 668.

271. Is there an updated Physical Habitat Claim for Claim 668?

Yes. The updated Physical Habitat flows for Claim Reach 668 are based on the data collected (Ex. 281-US-420) and analyzed and the resulting habitat-flow relationships developed for the target fish species and associated life stages. Ex. 281-US-421 contains the final habitat-flow relationships (WUA curves) for all target fish species and associated life stages.

The updated monthly flow values were derived in consideration of the determinations described above, and in accordance with the methods and procedures described in Section VII, and the eight decision steps described in Section VIII. Ultimately, these updated Physical Habitat flows represent those which I consider sufficient to provide for a healthy and productive habitat in the Wood River subbasin, including Claim Reach 668, at levels that meet, but do not exceed, the spatial needs of the target fish species.

The Wood River is a spring-dominated system whose channel morphology, substrate characteristics, and interrelationships of ecosystem components have evolved entirely around the provision of stable flows, coldwater temperatures, and good water quality. In addition, the Wood River is a large contributor of coldwater spring flow to Agency Lake and Upper Klamath Lake. This claim reach's special qualities include: 1) a large spring-dominant flow and thermal regime which affords relatively constant cool water in the summer months; 2) the reach is uniquely located in that it represents the segment of the Wood River extending from Agency Lake upstream to near its source, and provides important coldwater holding and refuge habitats from Agency Lake during summer months; 3) the reach provides important adfluvial redband trout spawning habitat seven months out of the year, as well as habitat for other adfluvial species (shortnose sucker, Lost River sucker, Klamath largescale sucker); 4) the reach provides the primary, upstream and downstream migratory corridor for adfluvial fish species (Lost River sucker, shortnose sucker, Klamath large scale sucker, and redband trout) from and to Agency Lake; and 5) the reach is anticipated to support anadromous salmonids upon reintroduction similar to the spawning habitat and migratory support currently provided to adfluvial fish species. Because of these special qualities, both individually and in combination, I considered Claim Reach 668 one of the "unique" streams or stream segments in the basin (see Section VIII at questions 259 and 260-Step Two). As a result, the IFIM/PHABSIM flow was based on providing the greatest amount of potential habitat of the priority species/lifestage.

Table IX-668-2 encapsulates the derivation process of each monthly claim resulting in a flow which was the lesser of: 1) the IFIM/PHABSIM-based flow for the priority species/lifestage for that month (representing the flow that provides 100 percent of the potential amount of habitat) as may be conditioned by post-spawning incubation flows (representing 2/3 of the IFIM/PHABSIM spawning-based flow from the previous month); 2) the median flow (representing the hydrologic cap to the claim); or 3) the flow in the 1999 Physical Habitat Claim (representing the upper limit to the claim).

The monthly Riparian Habitat Claims for the claim reach are described in and supported by Dr. Chapin Direct Testimony at questions 61 and 61.

272. In light of the derivation process you described, how many of the monthly updated Physical Habitat flow values were based on the IFIM/PHABSIM flow; the incubation flow; the median flow cap; and the 1999 claim limit?

For Claim 668, the basis for the updated Physical Habitat flows was the IFIM/PHABSIM-based flows in eleven months (July through May); the incubation flow in no month; the median flow cap in no month; and the 1999 claim limit in one month (June). Overall, in eleven months the updated Physical Habitat flow values were less than the 1999 Physical Habitat flows. In one month, the updated Physical Habitat flow values were equal to the 1999 Physical Habitat flows.

Table IX-668-2. Updated Physical Habitat Claims and monthly instream flow values for Claim Reach 668 in the Wood River Subbasin, Oregon.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Priority Species and Lifestage	RT-s	RT-s	RT-s	RT-s	RT-s	LR-s	RT-a	RT-a	RT-a	RT-a	RT-s	RT-s
1999 Physical Habitat Claim Flow Values	200	200	200	200	200	134	130	130	130	130	130	200
100% WUA	125	125	125	125	125	160	125	125	125	125	125	125
Incubation Flow						83	83					
Median Flow	391	389	409	434	490	533	473	431	413	407	399	399
Updated IFIM/PHABSIM-Based Flows	125	125	125	125	125	160	125	125	125	125	125	125
Updated Physical Habitat Claim	**125**	**125**	**125**	**125**	**125**	**134**	**125**	**125**	**125**	**125**	**125**	**125**

RT-a = adult redband trout; RT-s = spawning redband trout;LR-s = spawning Lost River sucker

All values included in this table are presented in cubic feet per second (cfs).

273. You have described the overall process used in the selection of monthly Physical Habitat flow values in Sections VII and VIII. Please provide more detail regarding the specific determination of the monthly flow values for Claim 668.

The IFIM/PHABSIM-based flows were based on two lifestages (spawning and adult) for redband trout and one lifestage (spawning) for Lost River sucker. The discussion below is organized by periods of one or more months that share the same species/lifestage priority.

July – October

Based on information obtained from ODFW the IFIM/PHABSIM-based flows for this period were based on redband trout adults that would be found rearing, holding or moving through Claim Reach 668 (Figure VII-6). The flow that represents the greatest potential amount of redband trout adult habitat is 125 cfs (Table IX-668-2). This flow is lower than both the median flows and the 1999 claim flows. Therefore, the IFIM/PHABSIM flows represent the updated Physical Habitat flow values for the months of July through October (Table IX-668-2).

Because redband trout spawning takes place in May, redband trout egg incubation flow (2/3 of 125 cfs, or 83 cfs) was also considered for the month of July. However, the IFIM/PHABSIM based flows for adult redband trout are greater than the incubation flow, and therefore, the updated Physical Habitat flow values during this period remain as noted above.

November – May

Redband trout reportedly spawn within this reach during November through May (Figure VII-6). Therefore, redband trout spawning represents the species/lifestage priority during these months. The IFIM/PHABSIM flow that represents the greatest potential amount of redband trout spawning habitat is 125 cfs (Table IX-668-2). This flow is less than the median monthly flows and the 1999 claim flows. Therefore, the IFIM/PHABSIM flows constitute the updated Physical

Habitat Claim values for the November through May period (Table IX-668-2).

June

Lost River sucker reportedly spawn within this reach during June (Figure VII-6). Therefore, Lost River sucker spawning represented the species/lifestage priority during this month. The IFIM/PHABSIM-based flow that provides for the greatest potential amount of Lost River sucker spawning habitat is 160 cfs (Table IX-668-2). The IFIM/PHABSIM flow for this month is lower than the median flow but higher than the 1999 claim flow. Therefore, the 1999 claim flow constitutes the updated Physical Habitat flow claim value for the month of June (Table IX-668-2).

Because redband trout spawning takes place in May, redband trout egg incubation flow (2/3 of 125 cfs, or 83 cfs) was also considered for the month of June. However, the IFIM/PHABSIM based flow for spawning Lost River sucker is greater than the incubation flow and, therefore, the updated Physical Habitat flow value during this period remains as noted above.

274. Is there a conditional Physical Habitat Claim for Claim 668?

Yes. When anadromous fish are introduced to the Upper Klamath Basin, they will likely be present in Claim Reach 668 in July and August (during which Chinook adult would replace redband trout adult as a priority species) and September through November (during which Chinook spawning would replace redband trout adult as a priority species and lifestage) (Figure VII-6). Furthermore, for the months of December through February, protection of Chinook egg incubation will require sufficient flow for egg and embryo development.

275. When adjustments were made to the Physical Habitat Claims for the inclusion of Chinook, how many of the updated Physical Habitat flows were based on: the IFIM/PHABSIM flow; the incubation flow; the median flow cap; and the 1999 claim flow limit?

Compared to the flow values just provided for the Physical Habitat Claim based on current species, an anadromous fish presence will require adjustment of the updated Physical Habitat flows in the months of July through November.

With Chinook included as a priority species, the basis for the updated Physical Habitat flows was the IFIM/PHABSIM-based flows in six months (December through May); the incubation flow in no months; the median flow in no months; and the 1999 Physical Habitat Claim flows in six months (June-November). Overall, in six months, the conditional Physical Habitat flow values were less than the 1999 Physical Habitat flows and, in six months, the conditional Physical Habitat flow values were equal to the 1999 claims.

Table IX-668-3. Conditional Updated Physical Habitat Claims and monthly instream flow values for Claim Reach 668 in the Sprague River Subbasin, Oregon.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Priority Species and Lifestage	RT-s	RT-s	RT-s	RT-s	RT-s	LR-s	CH-a	CH-a	CH-s	CH-s	CH-s	RT-s
1999 Physical Habitat Claim Flow Values	200	200	200	200	200	134	130	130	130	130	130	200
100% WUA	125	125	125	125	125	160	280	280	240	240	240	125
Incubation Flow	87	87				83	83					87
Median Flow	391	389	409	434	490	533	473	431	413	407	399	399
Conditional IFIM/PHABSIM-Based Flows	125	125	125	125	125	160	280	280	240	240	240	125
Conditional Physical Habitat Claim	**125**	**125**	**125**	**125**	**125**	**134**	**130**	**130**	**130**	**130**	**130**	**125**

RT-s = spawning redband trout; LR-s = spawning Lost River sucker; CH-a = adult Chinook; CH-s = spawning Chinook

All values included in this table are presented in cubic feet per second (cfs).

276. Please provide more detail regarding the determination of the monthly flows for the conditional claim for Claim Reach 668.

As noted above, there were eight months (July through February) for which inclusion of Chinook would result in modifications to the priority species and lifestage. These included the months of July and August in which Chinook adults would be present, the months of September through November which reflect the spawning period for Chinook, and December through February in which Chinook egg incubation would occur (Table IX-668-3).

July and August (conditional claim)

Information on species periodicity predicts that adult Chinook salmon will use Claim Reach 668 during the months of July and August (Figure VII-6). The IFIM/PHABSIM-based flow that represents the greatest potential amount of Chinook salmon adult habitat is 280 cfs (Table IX-668-3). The IFIM/PHABSIM-based flows for these months are lower than the median flows, but higher than the 1999 claim flows. Therefore, the conditional Physical Habitat flow values were adjusted to the 1999 Physical Habitat flows for the months of July and August (Table IX-668-3).

Because redband trout spawning takes place in May, redband trout egg incubation flow (2/3 of 125 cfs or 83 cfs) was also considered for the month of July. However, the IFIM/PHABSIM based flow for adult Chinook salmon is greater than the incubation flow and, therefore, the conditional Physical Habitat flow value for July remains as noted above.

September – November (conditional claim)

Chinook salmon are predicted to spawn in Claim Reach 668 from September through November (Figure VII-6). The IFIM/PHABSIM-based flow that provides 100 percent of the potential amount of Chinook salmon spawning habitat is 240 cfs (Table IX-668-3). The

IFIM/PHABSIM flows are lower than the median flows, but higher than the 1999 Physical Habitat flows for September through November. Therefore, the conditional Physical Habitat flow values during this period were adjusted to the 1999 Physical Habitat flows (Table IX-668-3).

December – May (conditional claim)

For this period, the species and lifestage priority remain redband trout spawning. Thus, no conditional Physical Habitat Claims were necessary for this reach during the months of December through May (Table IX-668-3).

Because Chinook spawning takes place in November, egg incubation flows (2/3 of 130 cfs, or 87 cfs) were also considered for the months of December through February. However, the IFIM/PHABSIM based flow for redband trout spawning is greater than the incubation flow and, therefore, the updated Physical Habitat flow values during this period remain as noted above.

June (conditional claim)

For this period, the species and lifestage priority remains Lost River sucker spawning. Thus, no conditional Physical Habitat Claims were necessary for this reach during the month of June (Table IX-668-3).

CLAIM 669 – CROOKED CREEK

277. Please describe the stream reach associated with Claim 669.

Claim 669 encompasses Crooked Creek in its entirety and extends from its confluence with the Wood River upstream approximately 10.5 miles to its headwater spring source (hereinafter called "Claim Reach 669"). See OWRD Ex. 47 at 15 describing the upper and lower boundaries of the Claim Reach; also see Figure IX-669-1 and Figure IX-669-2.

Physically, Crooked Creek is a low gradient (0.1%) stream that possesses a meandering, unconfined channel averaging approximately 45 feet wide (Ex. 281-US-416; Ex. 281-US-422). Crooked Creek is spring-dominated and exhibits relatively little variation in flow over the year. Peak median flow (94 cfs) in the claim reach typically occurs in late spring and the low median flow (80 cfs) occurs in July (Figure IX-669-3). The lower portion of the claim reach has been highly modified by agricultural activities.

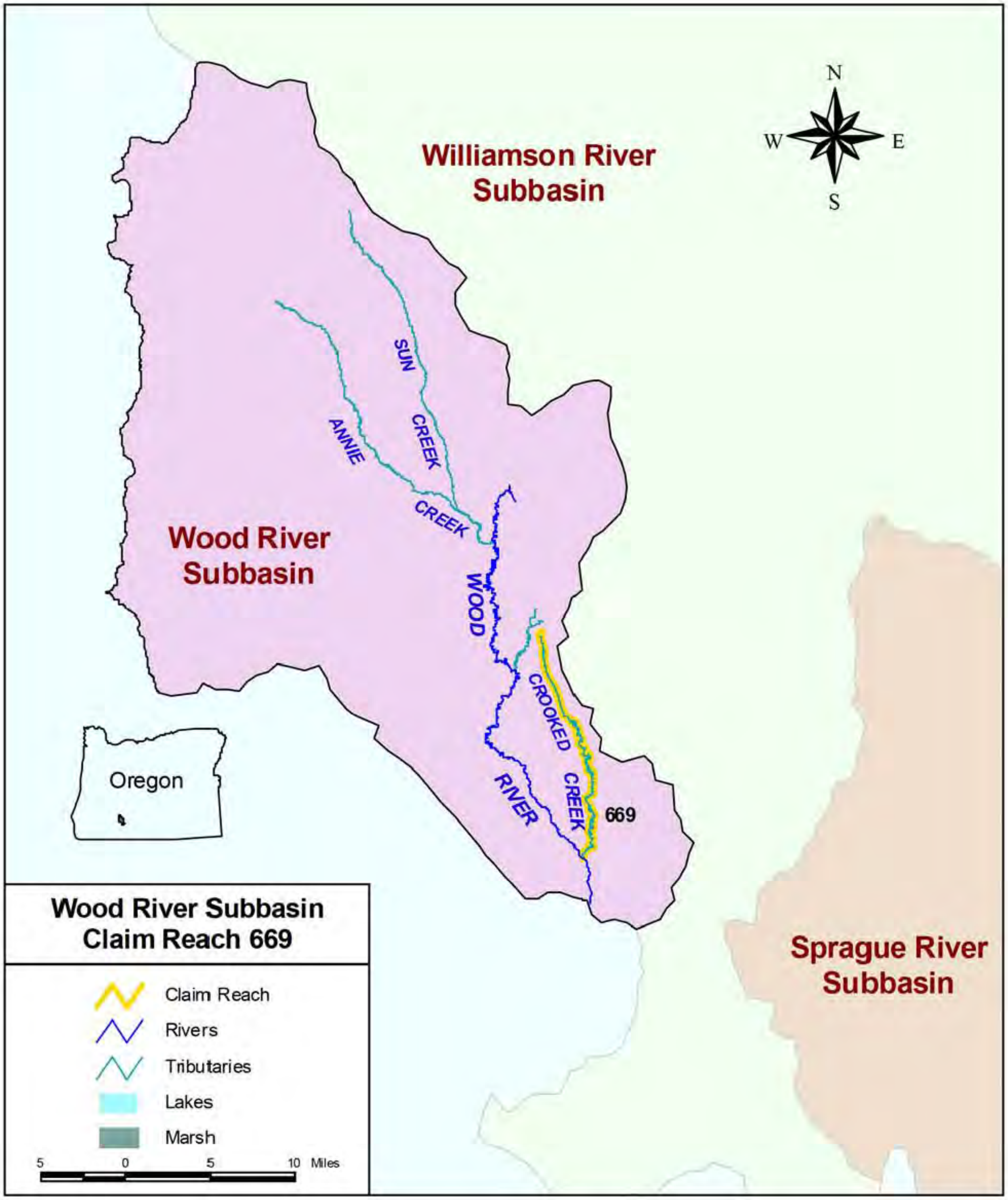

Figure IX-669-1. Claim Reach 669. Crooked Creek (Wood River subbasin); reach highlighted in yellow.

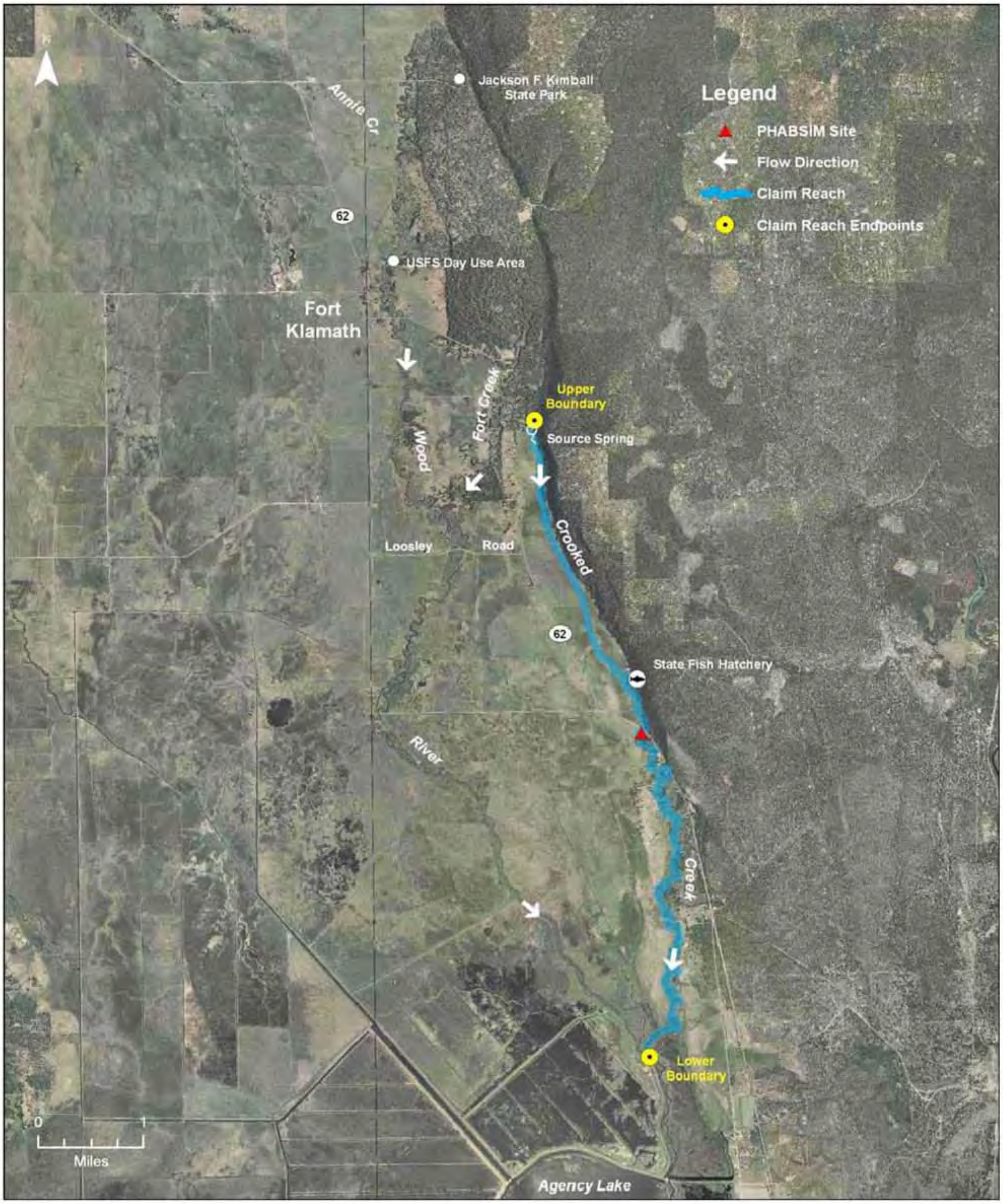

Figure IX-669-2. Orthographic photograph of Claim Reach 669 (Oregon Imagery Explorer 2007).

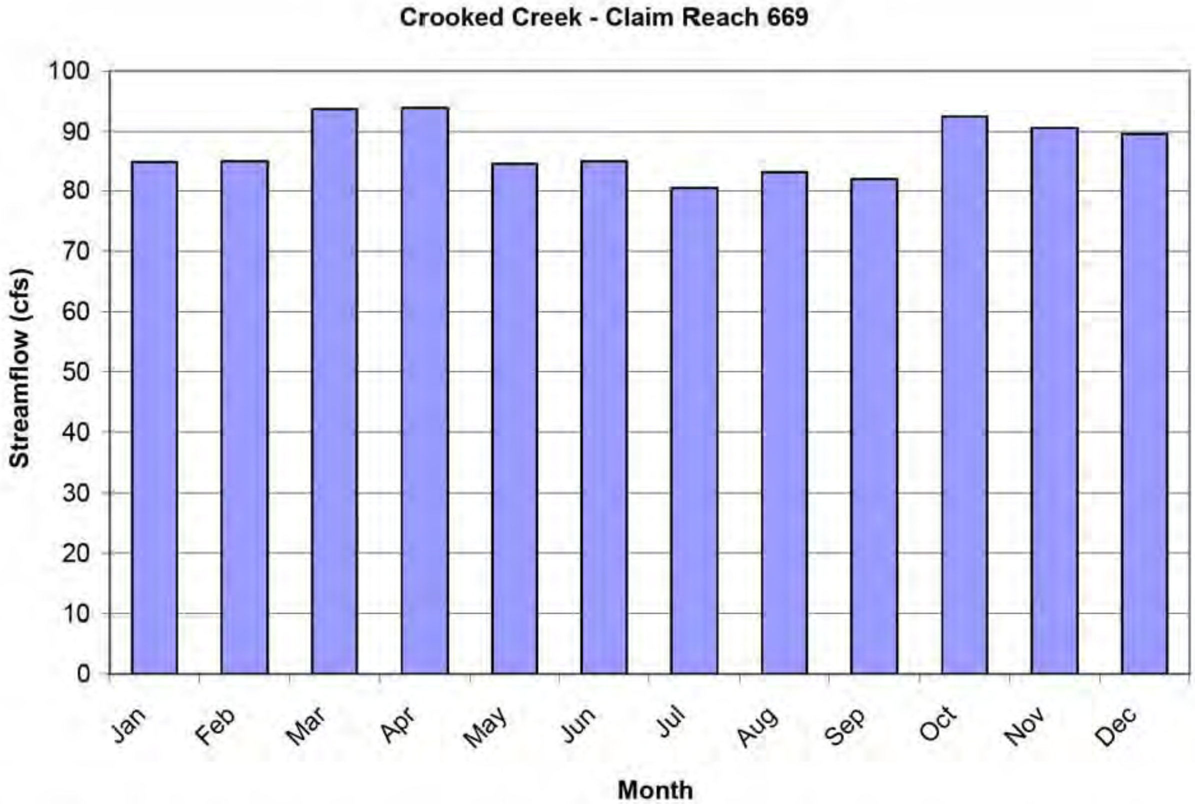

Figure IX-669-3. Crooked Creek monthly hydrograph (median flow values) at confluence with Wood River (Claim Reach 669) (Cooper 2004).

278. Are you familiar with this reach of Crooked Creek that comprises Claim Reach 669?

Yes. I have visited several portions of Claim Reach 669 multiple times over the past 20 years, including the Highway 62 crossing near the midpoint of the claim reach, the Klamath State Fish Hatchery, and the headwaters spring. I have also visited and inspected the detailed study site located just north of the Highway 62 crossing (Figure IX-669-2) and participated in the collection of invertebrate samples within the study site. Most recently, I completed a field reconnaissance of the detailed IFIM/PHABSIM site in June 2006 to check transect locations and survey points and assess overall habitat conditions. I have also flow over the lower most extent of the claim reach near the confluence of Crooked Creek and the Wood River (Claim Reach 668).

279. Please describe the stream environment associated with Claim Reach 669.

Based on my observations and information from other sources, the stream environment associated with Claim Reach 669 is as follows. Riparian vegetation along Crooked Creek is similar to that along the Wood River. Herbaceous vegetation composed of sedges, rushes, and grasses dominate the riparian vegetation, and scattered stands of willow, aspen, and cottonwood exist along the stream. In some areas, marsh-like conditions are present. Much of the riparian area along the claim reach is subject to cattle grazing, which has negatively impacted vegetation along the streambank and reduced willow cover (Dr. Chapin Direct Testimony at question 61).

With respect to fish habitat, a survey made by ODFW in a 5.2-mile section of the central portion of the claim reach described the section as glide habitat (85%) and pool habitat (15%) (Ex. 281-US-423). Pools were found at sharp meander bends and were distinguished from similar glide habitat by maximum depths usually greater than 5.0 feet (Ex. 281-US-423). Visual estimates during the survey identified only 624 square feet of "poor" pumice gravel suitable for salmonid spawning. About 430 square feet of high-quality spawning gravel was placed near a major spring that enters the claim reach near the Klamath State Fish Hatchery. Other than these two small areas of gravel, the streambed within the central portion of the reach is comprised of sand and organics (96%) (Ex. 281-US-423).

The lower portion of Claim Reach 669 has a "canal-like" appearance and consists of glide habitat (73%) and pool habitats (27%) formed by sharp meander bends (Ex. 281-US-423). Visual estimates made by ODFW (Ex. 281-US-423) in a 3.0 mile section of the lower portion of the claim reach reported no riffles and only scattered pumice gravel not suitable for spawning. The streambed within the lower portion of the claim reach consists of sand and organics (99%) (Ex. 281-US-423).

280. Please describe the target fish species that currently, and in the future will, utilize this reach.

The target fish species that currently occur in this reach include redband trout and Klamath largescale sucker. Redband trout spawning habitat is limited to a few locations as noted above. Undercut banks throughout the surveyed portion of the reach provide excellent cover for juvenile rearing (Ex. 281-US-423, Ex. 281-US-424).

Lost River and shortnose suckers historically spawned in the claim reach, with sucker spawning last documented in 1987 (Markle and Cooperman 2001). Larval Lost River suckers have been collected from this reach (Ex. 281-US-414), possibly the offspring of suckers from Upper Klamath or Agency Lakes. Portions of the claim reach are also designated as critical habitat for Lost River and shortnose suckers (USFWS 1994; White et al. 1995).

Other fish species that inhabit Claim Reach 669 include speckled dace, brown trout, brook trout, and unidentified sculpin and lamprey species (Ex. 281-US-413; KBRT 2003).

Claim Reach 669 would also be important relative to Chinook salmon, a species historically present in the basin and that is planned for reintroduction into the Upper Klamath Basin (Hooton and Smith 2008). In addition to providing spawning habitat within the upper portion of the reach, Claim Reach 669 represents a necessary migration portal for downstream migration of juveniles and smolts that are moving downstream to the Wood River en route to the ocean.

281. What field data were collected and used to develop the updated Physical Habitat flow values for Claim 669?

The collection of field data for this site followed the general methods and sampling procedures described in Section VII. The detailed sampling site for this reach was established in May 2004 and based on habitat mapping conducted on a section of the river approximately 1500 feet long. Stream habitat diversity was low, consisting only of run habitat (100%) (Ex. 281-US-422). Because of the monotypic nature of the habitat types, a total of three (3) PHABSIM transects were established and sampled during three separate visits. A summary of the data collection is provided in Table IX-669-1 and a photograph of transect number two from the sample site is provided in Figure IX-669-2.

Table IX-669-1. Dates, habitat types sampled, and number of transects measured during each field survey completed for Claim Reach 669.

Survey Date	Habitat Type(s) Sampled	Number of Transects
05/15/2004	Run	3
06/27/2004	Run	3
08/19/2004	Run	3

Figure IX-669-4. Crooked Creek (Claim Reach 669), IFIM/PHABSIM sample site at Run Transect 2, on May 15, 2004.

Ex. 281-US-422 includes copies of the field data collected and used to develop the updated Physical Habitat flow values for Claim 669.

282. Is there an updated Physical Habitat Claim for Claim 669?

Yes. The updated Physical Habitat flow values for Claim Reach 669 are based on the data collected (Ex. 281-US-425) and analyzed and the resulting habitat-flow relationships developed for the target fish species and associated life stages. Ex. 281-US-426 contains the final habitat-flow relationships (WUA curves) for all target fish species and associated life stages.

The updated monthly flow values were derived in consideration of the determinations described above, and in accordance with the methods and procedures described in Section VII, and the eight decision steps described in Section VIII. Ultimately, these updated Physical Habitat flows represent those which I consider sufficient to provide for a healthy and productive habitat in the Wood River subbasin, including Claim Reach 669, at levels that meet, but do not exceed the spatial needs of the target fish species.

Crooked Creek is a spring-dominated system whose channel morphology, substrate characteristics, and interrelationships of ecosystem components have evolved entirely around the provision of stable flows, coldwater temperatures, and good water quality. This claim reach's special qualities include: 1) a large spring-dominant flow and thermal regime which affords relatively constant cool water in the summer months; 2) the reach provides substantial adfluvial redband trout spawning habitat seven months out of the year; and as well habitat for other adfluvial species (shortnose sucker, Lost River sucker, and Klamath Largescale sucker), and 3) the reach provides habitat anticipated to support anadromous salmonids upon reintroduction similar to the spawning and rearing habitats currently provided to adfluvial fish species. Because of these special qualities, both individually and in combination, I considered Claim Reach 669 one of the "unique" streams or stream segments in the basin (see Section VIII at questions 259 and 260-Final Step Two). As a result, the IFIM/PHABSIM flow was based on providing the greatest amount of potential habitat of the priority species/lifestage.

Table IX-669-2 encapsulates the derivation process of each monthly claim resulting in a flow which was the lesser of: 1) the IFIM/PHABSIM-based flow for the priority species/lifestage for that month (representing the flow that provides 100 percent of the potential amount of habitat) as may be conditioned by post-spawning incubation flows (representing 2/3 of the

IFIM/PHABSIM spawning-based flow from the previous month); 2) the median flow (representing the hydrologic cap to the claim); or 3) the flow in the 1999 Physical Habitat Claim (representing the upper limit to the claim).

The monthly Riparian Habitat Claims for the claim reach are described in and supported by Dr. Chapin Direct Testimony at questions 61 and 62.

283. In light of the derivation process you described, how many of the monthly updated Physical Habitat flow values were based on the IFIM/PHABSIM flow; the incubation flow; the median flow cap; and the 1999 claim limit?

For Claim 669, the basis for the updated Physical Habitat flows was the IFIM/PHABSIM-based flows in all twelve months; the incubation flow in no month; the median flow cap in no month; and the 1999 claim limit in no month. Overall, in all twelve months the updated Physical Habitat flows were less than the 1999 Physical Habitat flows.

Table IX-669-2. Updated Physical Habitat Claims and monthly instream flow values for Claim Reach 669 in Crooked Creek (Wood River Subbasin), Oregon.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Priority Species and Lifestage	RT-s	RT-s	RT-s	RT-s	RT-s	RT-a	RT-a	RT-a	RT-a	RT-a	RT-s	RT-s
1999 Physical Habitat Claim Flow Values	88	88	88	88	88	88	88	88	88	88	88	88
100% WUA	70	70	70	70	70	70	70	70	70	70	70	70
Incubation Flow						47	47					
Median Flow	84.9	85.0	93.6	93.8	84.6	85.0	80.5	83.2	81.9	92.5	90.6	89.6
Updated IFIM/PHABSIM-Based Flows	70	70	70	70	70	70	70	70	70	70	70	70
Updated Physical Habitat Claim	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**

RT-a = adult redband trout; RT-s = spawning redband trout

All values included in this table are presented in cubic feet per second (cfs).

284. You have described the overall process used in the selection of monthly Physical Habitat flow values in Sections VII and VIII. Please provide more detail regarding the specific determination of the monthly flow values for Claim 669.

The IFIM/PHABSIM-based flows were based on two lifestages (spawning and adult) of one target fish species, redband trout. The discussion below is organized by periods of one or more months that share the same species/lifestage priority.

June – October

Based on information obtained from ODFW (Figure VII-6), the IFIM/PHABSIM-based flows for this period were based on redband trout adults that would be found rearing, holding or moving through Claim Reach 669. The flow that provides for the greatest potential amount of redband trout adult habitat is 70 cfs (Table IX-669-2). This flow is lower than both the median flows and the 1999 claim flows. Therefore, the IFIM/PHABSIM flows constitute the updated Physical Habitat Flows for the months of June through October (Table IX-669-2).

Because redband trout spawning takes place in May, redband trout egg incubation flow (2/3 of 70 cfs, or 47 cfs) was also considered for the months of June and July. However, the IFIM/PHABSIM based flow for redband trout adult is greater than the incubation flow and, therefore, the updated Physical Habitat flow values during this period remain as noted above.

November – May

Redband trout reportedly spawn within this reach during November through May (Figure VII-6). Therefore, redband trout spawning represented the species/lifestage priority during these months. The IFIM/PHABSIM flow that provides for the greatest potential amount of redband trout spawning habitat is 70 cfs (Table IX-669-2). This flow is less than the median monthly flows and the 1999 claim flows. Therefore, the IFIM/PHABSIM flows constitute the updated Physical Habitat Claims for the November through May period (Table IX-669-2).

285. Is there a conditional Physical Habitat Claim for Claim 669?

Yes. When Chinook salmon are reintroduced to the Upper Klamath Basin, they will likely be present from June through October (during which Chinook adult would replace redband trout adult as a priority species) (Figure VII-6. Although it is assumed that there is sufficient suitable gravel available within the claim reach for Chinook salmon spawning, the IFIM/PHABSIM sampling did not identify gravels suitable for Chinook salmon spawning. Therefore, Chinook adult remains as the priority species and lifestage in September and October during which Chinook spawning would normally occur.

286. When adjustments were made to the Physical Habitat Claims for the inclusion of Chinook, how many of the updated Physical Habitat flows were based on: the IFIM/PHABSIM flow; the incubation flow; the median flow cap; and the 1999 claim flow limit?

Compared to the flow values just provided for the Physical Habitat Claim based on current species, anadromous fish presence requires re-evaluation of the updated Physical Habitat flows in the months of June through October.

With Chinook salmon included as a priority species, the basis for the updated Physical Habitat flows was the IFIM/PHABSIM-based flows in all twelve months (January -December); the Chinook salmon incubation flow in no month; the median flow cap in no month; and the 1999 Physical Habitat flows in no month. Overall, in all twelve months, the conditional Physical Habitat flows were less than the 1999 Physical Habitat flows.

Table IX-669-3. Conditional Updated Physical Habitat Claims and monthly instream flow values for Claim Reach 669 in Crooked Creek (Wood River Subbasin), Oregon.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Priority Species and Lifestage	RT-s	RT-s	RT-s	RT-s	RT-s	CH-a	CH-a	CH-a	CH-a	CH-a	RT-s	RT-s
1999 Physical Habitat Claim Flow Values	88	88	88	88	88	88	88	88	88	88	88	88
100% WUA	70	70	70	70	70	70	70	70	70	70	70	70
Incubation Flow						47	47					
Median Flow	84.9	85.0	93.6	93.8	84.6	85.0	80.5	83.2	81.9	92.5	90.6	89.6
Conditional IFIM/PHABSIM-Based Flows	70	70	70	70	70	70	70	70	70	70	70	70
Conditional Physical Habitat Claim	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**

RT-s = spawning redband trout; RT-a = adult redband trout; CH-a = adult Chinook
All values included in this table are presented in cubic feet per second (cfs).

287. Please provide more detail regarding the determination of the monthly flows for the conditional claim for Claim Reach 669.

As noted above, there are five months (June-October) for which inclusion of Chinook would result in modifications to the priority species and lifestage as already described. The discussion below is organized by periods of one or more months that share the same species/lifestage priority.

June – October (conditional claim)

Information obtained from a variety of sources predicts that upon reintroduction, Chinook salmon adults will use Claim Reach 669 during the months of June through October for holding/staging prior to migration to suitable spawning locations (Figure VII-6). The IFIM/PHABSIM-based flow that provides for the greatest potential amount of Chinook salmon adult habitat is 70 cfs (Table IX-669-3). The IFIM/PHABSIM flows are lower than both the 1999 Physical Habitat flows and the median monthly flows, and, therefore, constitute the conditional Physical Habitat flows for June through October (Table IX-669-3).

Because redband trout spawning takes place in May, redband trout egg incubation flow (2/3 of 70 cfs, or 47 cfs) was also considered for the months of June and July. However, the IFIM/PHABSIM based flow for redband trout adult is greater than the incubation flow and, therefore, the updated Physical Habitat flow values during this period remain as noted above.

November – May (conditional claim)

For this period, the species and lifestage priority remain redband trout spawning and the resulting IFIM/PHABSIM based flow was 70 cfs. Thus, no conditional Physical Habitat Claims were necessary for this reach during the months of November through May (Table IX-669-3).

CLAIM 670 – FORT CREEK

288. Please describe the stream reach associated with Claim 670.

Claim 670 encompasses the entirety of Fort Creek extending southward from its source at Reservation Spring, approximately 3.7 miles to its confluence with the Wood River (hereinafter called "Claim Reach 670"). See OWRD Ex. 48 at 13 describing the upper and lower boundaries of the Claim Reach; also see Figure IX-670-1 and Figure IX-670-2.

Physically, Fort Creek within Claim Reach 670 is a low gradient (0.08-0.3%), meandering channel averaging approximately 51 feet wide (Ex. 281-US-416, Ex. 281-US-427). The creek flows through a wide valley with a wide floodplain and low, forested terraces with abrupt slopes (Ex. 281-US-416). Due to the spring-dominated nature of Claim Reach 670, median flow fluctuates only slightly throughout the year, with the peak median monthly flow (85.1 cfs) typically occurring in June, and the low median flow (82.9 cfs) occurring in late spring (Figure IX-670-3).

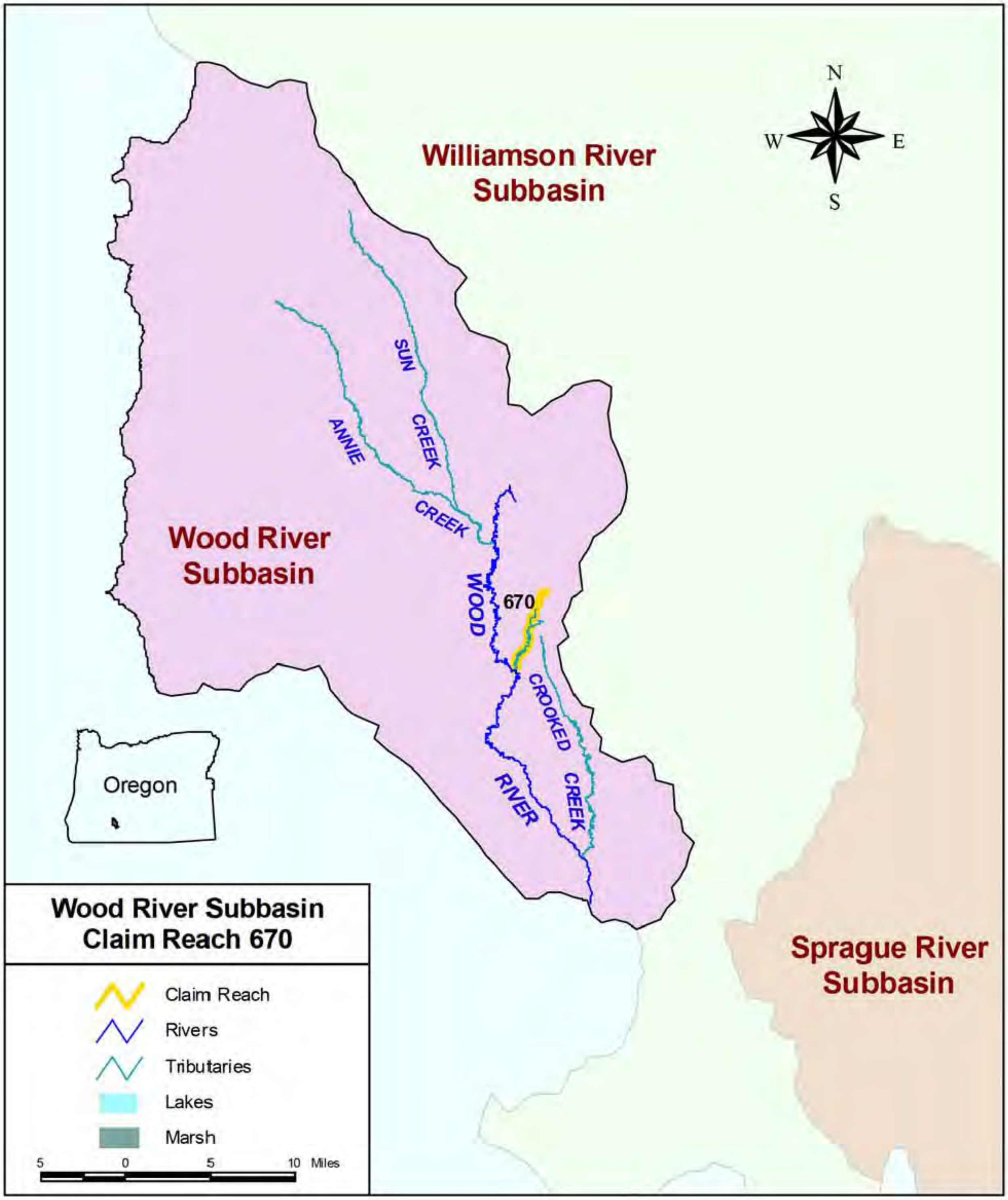

Figure IX-670-1. Claim Reach 670. Fort Creek subbasin with claim reach highlighted in yellow.

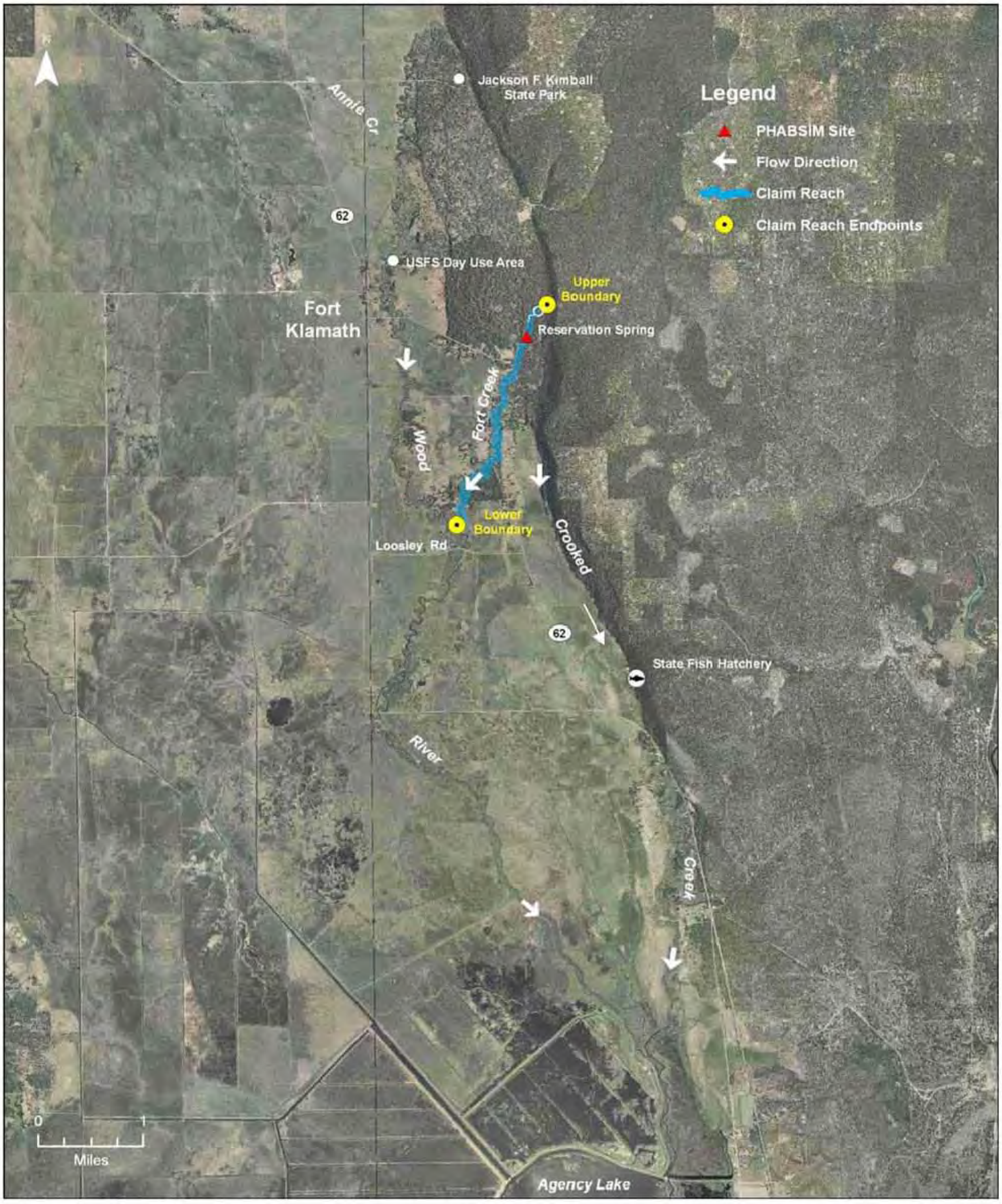

Figure IX-670-2. Orthographic photograph of Claim Reach 670 (Oregon Imagery Explorer 2007).

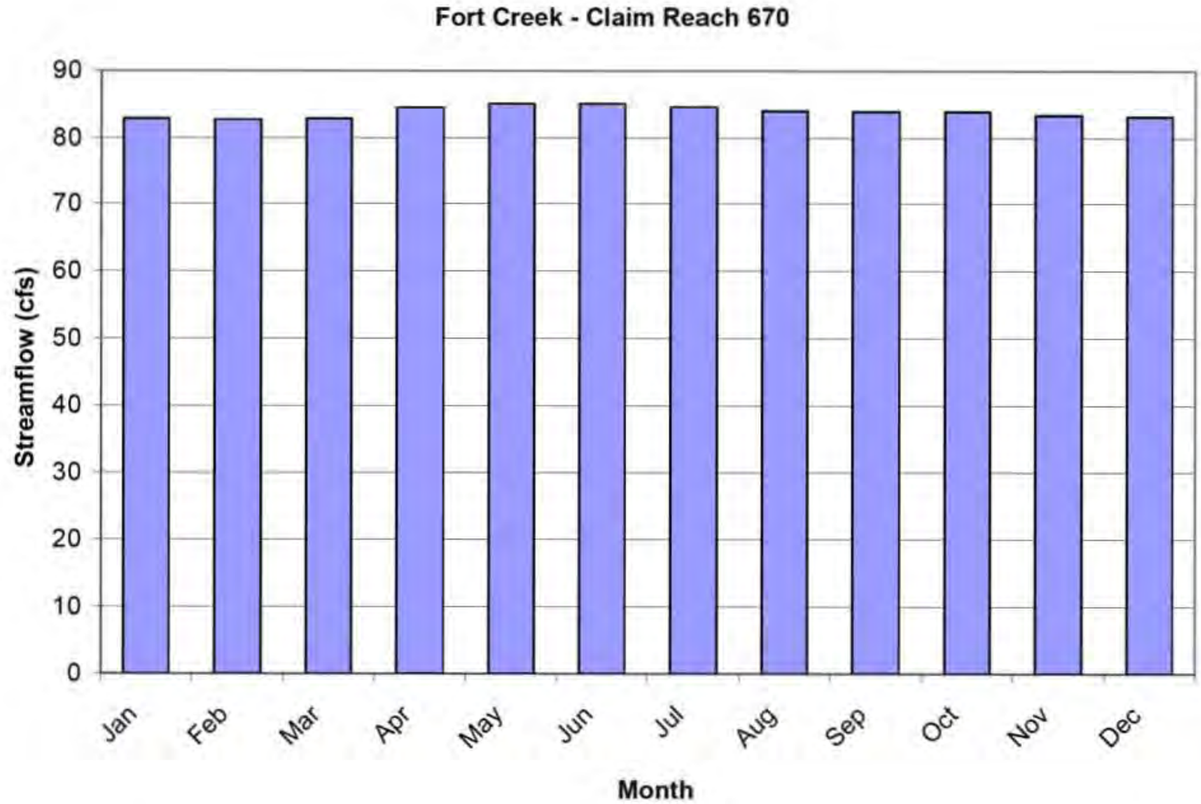

Figure IX-670-3. Fort Creek monthly hydrograph (median flow values) at confluence with Wood River (Cooper 2004).

289. Are you familiar with this reach of Fort Creek that comprises Claim Reach 670?

Yes. I have visited several portions of Claim Reach 670 multiple times over the past 20 years including the Highway 62 crossing near Fort Klamath, Oregon and the headwaters spring (Reservation Spring). I have also participated in snorkel and redd surveys as part of HSC data collection activities within Fort Creek, visited and inspected the detailed study site, and participated in the collection of invertebrate samples within the study site. Most recently, I completed a field reconnaissance of the detailed IFIM/PHABSIM site in June 2006 to check transect locations and survey points and assess overall habitat conditions.

290. Please describe the stream environment associated with Claim Reach 670.

Based on my observations and information from other sources, the stream environment associated with Claim Reach 670 is as follows. The lower portion of the claim reach flows through a flat valley bottom, with riparian vegetation composed of sedge, rushes, grasses, and scattered stands of willow and pine trees (Ex. 281-US-428). Shrub cover is generally higher than in claim reaches 668 and 669. The upper portion of the reach flows through a conifer forest to its source, Reservation Spring. Along this upper portion of the reach, riparian vegetation is limited to a narrow strip composed of diverse shrub species as well as sedges, rushes, and grasses (Dr. Chapin Direct Testimony at question 62).

With respect to fish habitat, a survey made by ODFW (Ex. 281-US-428) in a 0.5-mile section of the upper portion of the claim reach identified the majority of the upper portion of Claim Reach 670 as riffle habitat (76%), while the remainder was identified as glide habitat (24%). Visual estimates during the survey indicated a total of 1,883 square feet of poorly sorted pumice gravel were present in the survey portion. The streambed within the upper portion of the claim reach is composed of sand (30%), gravel (29%), and cobble (40%) (Ex. 281-US-428).

The lower portion of Claim Reach 670 consists primarily of glide habitat with a few scour pools at meander bends (Ex. 281-US-428). Although high amounts of stable woody debris were noted, wood was not considered a pool-forming factor (Ex. 281-US-428). Visual estimates made by ODFW (Ex. 281-US-428) in a 0.7- mile section of the lower portion of the claim reach indicated a total of 460 square feet of pumice gravel present that would be suitable for spawning. The streambed within the lower portion of the Claim Reach is generally dominated by fine substrates consisting of sands and organics (84%) and the few areas that contained gravel and cobble substrate (16%) were highly embedded with sand (Ex. 281-US-428).

291. Please describe the target fish species that currently, and in the future will, utilize this reach.

The target fish species that currently occur in this reach are redband trout and Klamath largescale sucker. Redband trout spawning habitat is primarily limited to the riffle areas located in the upper portion of Claim Reach 670. Undercut banks throughout the surveyed portion of the claim reach provide ample cover for juvenile rearing (Ex. 281-US-428). Bull trout historically used this reach (Buchanan et al. 1997).

Lost River and shortnose suckers historically spawned in the claim reach, with sucker spawning last documented in the late 1980s and early 1990s (Markle and Cooperman 2001). Portions of the claim reach are also designated as critical habitat for Lost River and shortnose suckers (USFWS 1994; White et al. 1995).

Other fish species that inhabit Claim Reach 670 include brown trout and brook trout (Ex. 281-US-413; KBRT 2003), and marbled sculpin and Pacific lamprey (Ex. 281-US-429).

Claim Reach 670 will be especially important to Chinook salmon upon reintroduction into the Upper Klamath Basin (Hooton and Smith 2008). In addition to providing spawning habitat within the upper portion of the reach, Claim Reach 670 represents a migration portal for downstream migrating Chinook salmon juveniles and smolts that are moving to the Wood River en route to the ocean.

292. What field data were collected and used to develop the updated Physical Habitat flow values for Claim 670?

The collection of field data for this site followed the general methods and sampling procedures described in Section VII. The detailed sampling site for this reach was established in May 2004 and was based on habitat mapping conducted on a section of the river approximately

1,281 feet long. Because of the monotypic nature of the habitat types (i.e., entirely riffle type habitat), a total of three (3) PHABSIM transects were established and sampled during three separate visits. A summary of the data collection is provided in Table IX-670-1 and a photograph of the sample site is provided in Figure IX-670-3.

Table IX-670-1. Dates, habitat types sampled, and number of transects measured during each field survey completed for Claim Reach 670.

Survey Date	Habitat Type(s) Sampled	Number of Transects
05/14/2004	Riffle	3
06/27/2004	Riffle	3
08/19/2004	Riffle	3

Figure IX-670-4. Fort Creek (Claim Reach 670), IFIM/PHABSIM sample site at Riffle Transect 1, on August 19, 2004.

Ex. 281-US-427 includes copies of the field data collected and used to develop the updated Physical Habitat flow values for Claim 670.

293. Is there an updated Physical Habitat Claim for Claim 670?

Yes. The updated Physical Habitat flow values for Claim Reach 670 are based on the data collected (Ex. 281-US-430) and analyzed and the resulting habitat-flow relationships developed for the target fish species and associated life stages. Ex. 281-US-431contains the final habitat-flow relationships (WUA curves) for all target fish species and associated life stages.

The updated monthly flow values were derived in consideration of the determinations described above, and in accordance with the methods and procedures described in Section VII, and the eight decision steps described in Section VIII. Ultimately, these updated Physical Habitat flows represent those which I consider sufficient to provide for a healthy and productive habitat in the Wood River subbasin, including Claim Reach 670, at levels that meet, but do not exceed, the spatial needs of the target fish species.

Fort Creek is a spring-dominated system whose channel morphology, substrate characteristics, and interrelationships of ecosystem components have evolved entirely around the provision of stable flows, coldwater temperatures, and good water quality. This claim reach's special qualities include: 1) a large spring-dominant flow and thermal regime which affords relatively constant cool water in the summer months; 2) the reach provides substantial adfluvial redband trout spawning habitat seven months out of the year; and juvenile rearing habitat year round; and 3) the reach provides habitat anticipated to support anadromous salmonids upon reintroduction similar to the spawning and rearing habitats currently provided to adfluvial fish species. Because of these special qualities, both individually and in combination, I considered

Claim Reach 670 one of the "unique" streams or stream segments in the basin (see Section VIII at questions 259 and 260-Final Step Two). As a result, the IFIM/PHABSIM flow was based on providing the greatest amount of potential habitat of the priority species/lifestage.

Table IX-670-2 encapsulates the derivation process of each monthly claim resulting in a flow which was the lesser of: 1) the IFIM/PHABSIM-based flow for the priority species/lifestage for that month (representing the flow that provides the greatest amount of potential habitat) as may be conditioned by post-spawning incubation flows (representing 2/3 of the IFIM/PHABSIM spawning-based flow from the previous month); 2) the median flow (representing the hydrologic cap to the claim); or 3) the flow in the 1999 Physical Habitat Claim (representing the upper limit to the claim).

The monthly Riparian Habitat Claims for the claim reach are described in and supported by Dr. Chapin Direct Testimony at questions 61 and 62.

294. In light of the derivation process you described, how many of the monthly updated Physical Habitat flow values were based on the IFIM/PHABSIM flow; the incubation flow; the median flow cap; and the 1999 claim limit?

For Claim 670, the basis for the updated Physical Habitat flows was the IFIM/PHABSIM-based flows in all twelve months; the incubation flow in no month; the median flow cap in no month; and the 1999 claim limit in no month. Overall, in all twelve months the updated Physical Habitat flows were less than the 1999 Physical Habitat flows.

Table IX-670-2. Updated Physical Habitat Claims and monthly instream flow values for Claim Reach 670 in the Wood River Subbasin, Oregon.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Priority Species and Lifestage	RT-s	RT-s	RT-s	RT-s	RT-s	RT-a	RT-a	RT-a	RT-a	RT-a	RT-s	RT-s
1999 Physical Habitat Claim Flow Values	97	97	97	97	97	97	97	97	97	97	97	97
100% WUA	75	75	75	75	75	75	75	75	75	75	75	75
Incubation Flow						50	50					
Median	82.9	82.8	82.9	84.5	85.1	85.1	84.6	84.0	83.9	83.9	83.4	83.2
Updated IFIM/PHABSIM-Based Flows	75	75	75	75	75	75	75	75	75	75	75	75
Updated Physical Habitat Claim	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**

RT-a = adult redband trout; RT-s = spawning redband trout
All values included in this table are presented in cubic feet per second (cfs).

295. You have described the overall process used in the selection of monthly Physical Habitat flow values in Sections VII and VIII. Please provide more detail regarding the specific determination of the monthly flow values for Claim 670.

The IFIM/PHABSIM flows are based on two lifestages (adult and spawning) of one target fish species, redband trout. The discussion below is organized by periods of one or more months that share the same species/lifestage priority.

June – October

Based on information obtained from ODFW (Figure VII-6) and applying the lifestage and species prioritization process described in Section VII, the IFIM/PHABSIM-based flows for this period were based on redband trout adults that would be found rearing, holding or moving through Claim Reach 670. The IFIM/PHABSM flow that provide for the greatest potential amount of redband trout adult habitat is 75 cfs (Table IX-670-2). The IFIM/PHABSIM flows are lower than both the median flows and the 1999 Claim flows, and, therefore, constitute the updated Physical Habitat flows for the months of June through October (Table IX-670-2).

Because redband trout spawning takes place in May, redband trout egg incubation flow (2/3 of 75 cfs, or 50 cfs) was also considered for the months of June and July. However, the IFIM/PHABSIM-based flow for redband trout adult is greater than the incubation flow and, therefore, the updated Physical Habitat flow values during this period remain as noted above.

November – May

Redband trout reportedly spawn within this reach between November and May (Figure VII-6), and, therefore, redband trout spawning represented the species/lifestage priority during these months. The IFIM/PHABSIM-based flow that provides for the greatest potential amount of redband trout spawning habitat is 75 cfs (Table IX-670-2). The IFIM/PHABSIM flows are less than the median flows and the 1999 Physical Habitat Claims, and, therefore, constitute the updated Physical Habitat flows for the months of November through May.

296. Is there a conditional Physical Habitat Claim for Claim 670?

Yes. When anadromous fish are reintroduced to the Upper Klamath Basin, they will likely be present in June through August (during which Chinook adult would replace redband trout adult as a priority species) and September through November (during which Chinook spawning would replace redband trout adult as a priority species and lifestage) (Figure VII-6). Furthermore, for the months of December through February, protection of Chinook egg incubation will require sufficient flow for egg and embryo development.

297. When adjustments were made to the Physical Habitat Claims for the inclusion of Chinook, how many of the updated Physical Habitat flows were based on: the IFIM/PHABSIM flow; the incubation flow; the median flow cap; and the 1999 claim flow limit?

Compared to the flow values just provided for the Physical Habitat Claim based on current species, an anadromous fish presence will not require adjustment of the updated Physical Habitat flows in any month.

With Chinook salmon included as a priority species, the basis for the updated Physical Habitat flows was the IFIM/PHABSIM-based flows in all twelve months (January -December); the incubation flow in no month; the median flow cap in no month; and the 1999 Physical Habitat flows in no month. Overall, in all twelve months, the conditional Physical Habitat flows were less than the 1999 Physical Habitat flows.

Table IX-670-3. Conditional Physical Habitat Flow Claims and monthly instream flow values for Claim Reach 670 in the Wood River Subbasin, Oregon.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Priority Species and Lifestage	RT-s	RT-s	RT-s	RT-s	RT-s	CH-a	CH-a	CH-a	CH-s	CH-s	CH-s	RT-s
1999 Physical Habitat Claim Flow Values	97	97	97	97	97	97	97	97	97	97	97	97
100% WUA	75	75	75	75	75	75	75	75	75	75	75	75
Incubation Flow	50	50				50	50					50
Median Flow	82.9	82.8	82.9	84.5	85.1	85.1	84.6	84.0	83.9	83.9	83.4	83.2
Updated IFIM/PHABSIM-Based Flows	75	75	75	75	75	75	75	75	75	75	75	75
Updated Physical Habitat Flow Claim	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**	**75**

RT-s = spawning redband trout; CH-a = adult Chinook; CH-s = spawning Chinook
All values included in this table are presented in cubic feet per second (cfs).

298. Please provide more detail regarding the determination of the monthly flows for the conditional claim for Claim Reach 670.

As noted above, there were nine months (June through February) for which inclusion of Chinook result in modifications to the priority species and lifestage as already described. These included the months of June through August in which Chinook adults would be present, the months of September through November which reflect the spawning period for Chinook and the months of December through February in which Chinook egg incubation would occur (Table IX-670-3).

June – August (conditional claim)

Information on species periodicity predicts the use of Claim Reach 670 by adult Chinook salmon during the months of June through August (Figure VII-6). The IFIM/PHABSIM-based flow that provides the greatest amount of potential Chinook salmon adult habitat is 75 cfs (Table IX-670-3). The IFIM/PHABSIM flow is lower than both the 1999 Physical Habitat flows and the median monthly flows, and, therefore, constitutes the conditional Physical Habitat flows for the months of June through August.

Because redband trout spawning takes place in May, redband trout egg incubation flow (2/3 of 75 cfs, or 50 cfs) was also considered for the months of June and July. However, the IFIM/PHABSIM-based flow for redband trout adult is greater than the incubation flow and, therefore, the updated Physical Habitat flow values during this period remain as noted above.

September – November (conditional claim)

Periodicity information predicts that upon reintroduction, Chinook salmon will use Claim Reach 670 for spawning during the period September through November (Figure VII-6). The IFIM/PHABSIM-based flow that provides the greatest amount of potential Chinook salmon spawning habitat is 75 cfs (Table IX-670-3). The IFIM/PHABSIM flows are lower than both the 1999 Physical Habitat flows and the median monthly flows, and, therefore, constitutes the conditional Physical Habitat flows for the months of September through November.

December – May (conditional claim)

For this period, the species and lifestage priority remain redband trout spawning and the resulting IFIM/PHABSIM-based flows were 75 cfs for each month (Table IX-670-3). Thus, no conditional Physical Habitat Claims were necessary for this reach during the months of December through May (Table IX-670-3).

Because Chinook spawning takes place in November, egg incubation flows (2/3 of 75 cfs, or 50 cfs) were also considered for the months of December through February. However, the IFIM/PHABSIM based flow for redband trout spawning is greater than the incubation flow and, therefore, the updated Physical Habitat flow values during this period remain as noted above.

X. SUMMARY AND CONCLUSION

299. Please summarize your testimony.

In the preceding sections and pages of my testimony, I have described how the Physical Habitat Claims were developed and what the Physical Habitat Claims are for each of the Claim Reaches in the Wood River subbasin.

Briefly, in section II, I described the Physical Habitat and the Riparian Habitat components of the BIA's water rights claims in the Upper Klamath Basin. In section III, I described the Upper Klamath Basin and, more specifically, the Wood River subbasin. In section IV, I described the characteristics and components of a healthy and productive fish habitat. In section V, I generally described the methodology used to develop the Physical Habitat Claims, as well as other methodologies that are also available to evaluate habitat:flow relationships. In section VI, I described the current conditions of the streams within the Upper Klamath Basin, with specific examples from the Wood River subbasin. In section VII, I described the specific steps that were applied to gather reach-specific information in each Claim Reach of the Upper Klamath Basin. In section VIII, I described the final decision-making process that was employed to incorporate all of the information assembled over a two decade period to develop each Physical Habitat Claim. The information gathered and the processes described in sections II through VIII are the foundation I developed to establish the Physical Habitat Claims for each Claim Reach of the Wood River subbasin. Finally, in section IX, I provided a description of each Claim Reach in the Wood River subbasin, including a description of the riparian area surrounding the stream and the water habitat within the stream itself, and the flow-related values of each Physical Habitat Claim for each month of the calendar year necessary for a healthy and productive fish habitat, based on the IFIM/PHABSIM or Tennant methodology and the decision steps described in section VIII.

300. What are your conclusions regarding the flows necessary for a healthy and productive fish habitat?

My conclusion is that the Physical Habitat flow values I have described and the Riparian Habitat flow values described in Dr. Chapin Direct Testimony are those flows necessary to restore and/or maintain a healthy and productive fish habitat. In section IX, I have presented the specific flow values of the Physical Habitat Claims for each month and each Claim Reach. In response to questions 69 and 70 of Dr. Chapin's Direct Testimony, Dr. Chapin presented the specific flow values of the Riparian Habitat Claims for each month and each Claim Reach. These are the non-cumulative flows that are necessary to restore and/or maintain a healthy and productive fish habitat in the Wood River subbasin.

In sum, my conclusion is that the Physical Habitat flow values I described and the Riparian Habitat flow values described in Dr. Chapin Direct Testimony are those flows necessary to provide a healthy and productive fish habitat.

I have prepared Table X-1 which lists the necessary monthly Physical Habitat flow values and the monthly Riparian Habitat flow values for each Claim Reach of the Wood River subbasin.

Table X-1. Monthly Physical Habitat and Riparian Habitat flow values for Wood River Physical Habitat Claims and Riparian Habitat Claims, KBA Case #281

Claim Type	January	February	March	April	May	June	July	August	September	October	November	December
Claim Reach 668												
Physical Habitat Claim flow value	125	125	125	125	125	134	125	125	125	125	125	125
Conditional Physical Habitat flow value	125	125	125	125	125	134	130	130	130	130	130	125
Riparian Habitat Claim base flow value	0	0	270	286	323	352	312	277	254	255	263	0
Claim Reach 669												
Physical Habitat Claim flow value	70	70	70	70	70	70	70	70	70	70	70	70
Conditional Physical Habitat flow value	70	70	70	70	70	70	70	70	70	70	70	70
Riparian Habitat Claim base flow value	0	0	62	62	56	56	53	55	54	61	60	0
Claim Reach 670												
Physical Habitat Claim flow value	75	75	75	75	75	75	75	75	75	75	75	75
Conditional Physical Habitat flow value	75	75	75	75	75	75	75	75	75	75	75	75
Riparian Habitat Claim base flow value	0	0	55	56	56	56	56	55	55	55	55	0

Further Affiant Sayeth Not.

Dated this 4 day of December, 2009

Dudley W. Reiser, Ph.D.
President, R2 Resource Consultants, Inc.

Subscribed and sworn before me this 4 day of December of 2009

Notary Public: Mario Thomas Valenti

My Commission Expires: 4-18-2013

MARIO THOMAS VALENTI
NOTARY
Apr 18 2013
PUBLIC
STATE OF WASHINGTON

APPENDIX A

Glossary

Accretion
A gradual increase in flow within a river, resulting from tributary inputs or upwelling groundwater.

Acre-foot
The quantity of water required to cover one acre of land to a depth of one foot; equivalent to 43,560 cubic feet of water or 325,851 gallons of water.

Adaptive Management
A structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously maximizes one or more resource objectives and, either passively or actively, accrues information needed to improve future management. Adaptive management is often characterized as "learning by doing."

Adfluvial
Fish that spend a part of their life cycle in lakes and return to rivers and streams to spawn.

Adjudication
A court proceeding to determine all rights to the use of water on a particular stream system or ground water basin.

Adult
Sexually mature individuals of a species.

Aggradation
A progressive build up of a channel bed with sediment over several years due to a normal sequence of scour and deposition, as distinguished from the rise and fall of the channel bed during a single flood.

Alluvial
Relating to, composed of, or found in alluvium.

Alluvium
Sediments deposited by erosional processes, usually by streams.

Anadromous
Fish that spend a part of their life cycle in the sea and return to freshwater streams to spawn.

Appropriative rights
"First in time, first in right" principle of allocating water rights based. Usually involves a user being allowed to take water from a particular source without regard to the contiguity of the land to the source.

Aquatic biota
Collective term describing the organisms living in or depending on the aquatic environment.

Aquatic insect
Insect that spends all or part of its life in water. Of the 29 insect orders, 11 members have some aquatic stages. Most of these have aquatic, immature stages, which usually take place in fresh water, sometimes in brackish water (very few species are truly marine); the adults are terrestrial, but in some orders there are species where all stages (egg, larva, and adult) live in the water. The orders Ephemeroptera (mayflies), Odonata (dragonflies), Plecoptera (stone-flies), Neuroptera (alder flies), Trichoptera (caddis flies), Lepidoptera (butterflies and moths), and Diptera (true flies) have aquatic larvae, but the adults are terrestrial.

Aquatic life use
A beneficial use designation in which the water body provides suitable habitat for survival and reproduction of desirable fish, shellfish, and other aquatic organisms.

Aquifer
A geologic formation that will yield water to a well in sufficient quantities to make the production of water from this formation feasible for beneficial use; permeable layers of underground rock or sand that hold or transmit groundwater below the water table.

Armoring
The formation of an erosion-resistant layer of relatively large particles on a streambed or bank resulting from removal of finer particles by erosion.

Average Annual Flow
The rate at which water flows through a channel, determined by averaging daily measurements of the flow during one entire year.

Avulsion
A sudden or perceptible change in a river's margin, such as a change in course or loss of banks due to flooding.

Backwater
A small, generally shallow body of water attached to the main channel with little or no current of its own pushed back by a dam or current.

Bank
The sloping land bordering a stream channel that forms the usual boundaries of a channel. The bank has a steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.

Bank stability
Resistance of stream banks to erosion.

Bank-full channel depth
The maximum depth of a channel within a rifle segment when flowing at a bank-full discharge.

Bank-full flow
The discharge at which water completely fills a channel; the flow rate at which the water surface is level with the flood plain.

Bank-full width
The width of a river or stream channel between the highest banks on either side of a stream.

Bar
An accumulation of alluvium (gravel or sand) caused by a decrease in water velocity.

Base flow
The component of a flow regime that represents normal flow conditions sustained by groundwater between precipitation events.

Bathymetric
Related to the measurement of water depth within a water body.

Bed
The bottom of the stream channel; may be wet or dry.

Bed forms
Three-dimensional configurations of bed material, which are formed in streambeds by the action of flowing water.

Bed load
The particles in a stream channel that mainly move by bouncing, sliding, or rolling on or near the bottom of the stream.

Bed stability
Occurs when the average elevation of the streambed does not change significantly over time. Aggradation and degradation are the two forms of bed instability.

Bedrock
The solid rock or geologic surface underlying unconsolidated surface materials.

Benthic
Pertaining to the bottom of a body of water, on or within the bottom substrate material.

Benthic macroinvertebrates
Animals without backbones, living in or on the sediments, a size large enough to be seen by the unaided eye, and which can be retained by a U.S. Standard No. 30 sieve (28 openings/inch, 0.595-mm openings). Also referred to as benthos, infauna, or macrobenthos.

Biota
The organisms of a specific region or period considered as a group.

Boulder
Substrate particles larger than 10.0 inches in size, larger than cobble and not attached to bedrock.

Calibration
The validation of specific measurement techniques and equipment, or the comparison between measurements. In the context of PHABSIM, calibration is the process of adjusting input variables to minimize the error between predicted and observed water surface elevations.

Canopy
The overhanging cover formed by branches and foliage of trees and bushes.

Cascade
The steepest of riffle habitats. Unlike rapids, which have an even gradient, cascades consist of a series of small steps of alternating small waterfalls and shallow pools.

Channel
A natural or artificial watercourse that continuously or intermittently contains water, with definite bed and banks that confine all but overbank streamflows.

Channel morphology
The planform, pattern, shape, and structure of a stream channel.

Channelization
Natural or intentional straightening and/or deepening of streams so water moves faster and causes less flooding. Channelization can sometimes exacerbate flooding in other downstream areas.

Cobble
Substrate particles between 3.0 and 10.0 inches in size, larger than gravel and smaller than boulder.

Community
An interacting group of various species in a common location.

Community structure
The make-up or composition of a community. Among the factors that determine the overall structure of a community are the number of species (diversity) within it, the number of each species (abundance) found within it, the interactions among the species, and the ability of the community to return to normal after a disruptive influence.

Confidence interval
The computed interval with a given probability that the true value of the statistic – such as a mean, proportion, or rate – is contained within the interval.

Confined channel
A stream that is vertically contained, by incisement or hillslopes, and does not spread appreciably with increasing streamflow.

Confinement
Ratio of valley width (VW) to channel width (CW). Confined channel VW:CW <2; Moderately confined channel VW:CW 2-4; Unconfined channel VW:CW >4.

Confluence
The junction of two or more streams.

Connectivity
Refers to the movement and exchange of water, nutrients, sediments, organic matter, and organisms within a riverine ecosystem. Connectivity occurs laterally (between the stream and its floodplain), longitudinally (along the stream), vertically (between the stream and groundwater), and temporally.

Constrained channel
Stream channel that is prevented from moving laterally across the floodplain by steep valley sideslopes.

Consumptive use
The quantity of water not available for reuse. Evapotranspiration, evaporation, incorporation into plant tissue, and infiltration into groundwater are some of the reasons water may not be available for reuse.

Control; hydraulic control
A downstream channel feature--a channel constriction, a bedrock outcrop, a gravel bar, woody debris, an artificial structure--in the channel that physically influences the upstream water-surface elevation.

Cover
Protective shelter, objects within or immediately overhanging a stream that fish use to hide from predators.

Crest
The top edge of a dam, dike, spillway, or weir.

Cross-section
A diagram or drawing that shows features of a vertical section of the earth or a water column.

Cubic feet per second (cfs)
A standard measure of the total amount of water passing by a particular location of a river, canal, pipe or tunnel during a one second interval. One cfs is equal to 7.4805 gallons per second, 28.31369 liters per second, 0.028 cubic meters per second, or 0.6463145 million gallons per day (mgd). Also called second-feet.

Current meter
Instrument used to measure the velocity of water flow in a stream, measured in units of length per unit of time, such as feet per second (fps).

Datum
A geometric plane of known or arbitrary elevation used as a point of reference to determine the elevation, or change of elevation, of another plane (see gage datum).

Delta
An alluvial deposit made of rock particles (sediment, and debris) dropped by a stream as it enters a body of water.

Deposition
The laying down of material by erosion or transport by water or air.

Dewater
Remove or drain the water from a stream, pond or aquifer.

Diking
Bank protection accomplished by armoring the bank with erosion-resistant material.

Discharge
The rate of flow, or volume of water flowing past a given place (i.e., a cross section) within a given period of time, traditionally expressed as cubic feet per second (cfs).

Diversion
The act of, or structure built for, partially obstructing the flow of water in a channel in order to direct or alter the course of the water.

Drainage area
An area of land upstream of a particular point where all runoff from rain or snow melt drains downhill to the same outlet such as a river, lake, reservoir, estuary, wetland, sea or ocean. Also known as a catchment area or drainage basin.

Electrofishing
A biological collection method that uses electric current to facilitate capturing fishes.

Embeddedness
A measure of the degree that gravel and larger substrates are surrounded by fine particles (silt and sand).

Emergent vegetation
Rooted plants that can tolerate flooded soil but not extended periods of being completely submerged.

Endangered
Any species which is in danger of extinction throughout all or a significant portion of its range. These species have been given high priority for protection under the federal Endangered Species Act.

Endemic
Unique to or limited to a specific region or drainage.

Ephemeral stream
Stream that flows seasonally or periodically in response to rainfall or snowmelt.

Euphotic zone
Surface layer of an ocean, lake, or other body of water through which light can penetrate. Also known as the zone of photosynthesis.

Fines
Soil particles (sand, silts, clay particles, and organic debris parts) less than 0.25 inches in diameter.

Fish ladder
An artificial waterway composed of a series of stepped pools allowing fish to ascend a vertical gradient, usually built at one end of a dam.

Fish screen
Barrier installed to prevent fish from passing through a diversion structure or turbine.

Flashiness
A measure of a river or stream's tendency to carry a high percentage of its flow volume in large, infrequent events rather than more moderate flows that occur frequently.

FLIR
Forward looking infrared (FLIR) is an imaging technology that senses infrared radiation. Can be used for watershed temperature monitoring.

Flood frequency
How often, on average, a discharge of a given magnitude occurs at a particular location on a stream. Usually expressed as the probability that the discharge will exceed some size in a single year (for example, the 100 year flood has a 1 percent probability of being equaled or exceeded in any one year).

Floodplain
Land next to a river that becomes covered by water when the river overflows its banks.

Flow-duration curve
A graphic presentation of flow values plotted in descending order of magnitude against the percentage of time that a particular flow is equaled or exceeded. For example, the flow that equals the 90th percentile is the flow that 90 percent of all recorded flows for the river will equal or exceed. Also known as a flow exceedance curve.

Fluvial
Of or pertaining to the processes associated with rivers and streams and the deposits and landforms created by them. Also, relative to fish - fish that spend a part of their life cycle in large rivers and migrate to smaller streams and tributaries to spawn.

Foraging habitat
Areas where fish and wildlife search for food.

Fry
A recently hatched fish.

Ft/s
Feet per second, measure of velocity.

Gage datum
Elevation of the zero point of the reference gage from which gage height is determined as compared to sea level.

Gage height
Water-surface elevation referenced to the gage datum.

Gaging station
A specific site on a stream where systematic observations of streamflow or other hydrologic data are obtained.

Glide
Section of stream that has a smooth water surface, laminar flow path, and generally greater depth but no clear scour feature.

Gradient
The slope of the stream channel expressed as a percent of rise per unit length.

Gravel
Substrate particles between 0.25 and 3.0 inches in size, larger than sand and smaller than cobble.

Habitat
The native environment or specific surroundings where a plant or animal naturally grows or lives. Habitat includes physical factors such as temperature, moisture, and light together with biological factors such as the presence of food or predator organisms.

Habitat Suitability Curve (HSC)
A graph/mathematical equation describing the suitability for use by various species/lifestages of fish of areas within a stream channel related to water depth, velocity and substrate.

Headgate
A water control structure at the entrance to a conduit leading to an irrigation canal, flume or powerhouse.

Herbaceous
Herbaceous plants are those that lack woody stems and include broad-leaved plants (often called forbs) and narrow leaved grasses or grass-like plants, such as sedges and rushes.

High flow pulses
The component of an instream flow regime that represents short-duration, in-channel, high flow events following storm events. They maintain important physical habitat features and longitudinal connectivity along the river channel.

Holding area
Area used by fish for rest between periods of activity. Holding areas are generally characterized by low temperatures, cover, flow, or pools formed by rocks, fallen wood, and/or debris.

Hydraulic model
A computer model of a segment of river used to evaluate stream flow characteristics over a range of flows.

Hydraulic roughness
An estimate of the resistance to flow due to energy loss caused by friction between the channel and the water. Chezy's and Manning's roughness are two different ways to express this parameter.

Hydrograph
A chart that measures the amount of water flowing past a point as a function of time.

Hydrology
The study of the movement of water on the earth; includes surface water and groundwater.

Incised
Lowering of the streambed by erosion that occurs when the energy of the water flowing through a stream reach exceeds that necessary to erode and transport the bed material.

Incubation flow
Amount of streamflow considered suitable to promote the successful development and survival of fish eggs throughout their incubation period leading to hatching and emergence from the gravels.

Instream Flow Incremental Methodology (IFIM)
A five phase management and negotiation tool used for water allocation. The five phases are problem identification, study planning, study implementation, alternatives analysis, and problem resolution. Analysis is based on stream channel characteristics, water column dynamics, the historical flow record and target species habitat requirements or management goals. The Physical Habitat Simulation (PHABSIM) computer programs are part of the IFIM process.

Interbasin transfer
The physical transfer of water from one river basin to another.

Intermittent stream
Stream that has areas of surface and subsurface flow.

Interstices
The void or empty portion of rock or soil occupied by air or water.

Irrigation return flow
Water that is not consumptively used by plants and returns to a surface or ground water supply.

Iteroparous
Fish species that reproduce repeatedly during their lifetime.

Juvenile
Fish from one year of age until sexual maturity.

Laminar flow
Flow in which water moves smoothly in parallel layers or sheets. Streamlines are distinct and the flow directions at all points remain unchanged. It is characteristic of groundwater flow but can be used to describe surface waters.

Large Woody Debris (LWD)
Pieces of wood larger than 10 feet long and 6 inches in diameter, in a stream channel. Minimum sizes vary according to stream size and region.

Larval suckers
The young of suckers are called "larvae" when they first hatch because they are extremely small and not fully developed. Most larvae are relatively passive meaning they do not actively swim, hence the importance of flow to transport them downstream to areas of cover and food.

Limiting factor
Factors such as temperature, light, water (space/habitat), or a chemical that limits the existence, growth, abundance, or distribution of an organism.

Macrohabitat
Reach-scale habitat conditions in a section of river controlling longitudinal distribution of aquatic organisms, e.g., channel morphology, streamflow, water quality, temperature.

Macroinvertebrates
Animals without backbones of a size large enough to be seen by the unaided eye and which can be retained by a U.S. Standard No. 30 sieve (28 meshes per inch, 0.595 mm openings).

Macrophyte
Macroscopic plants in the aquatic environment. The most common macrophytes are the rooted vascular plants that are usually arranged in zones in aquatic ecosystems and restricted in their area by the extent of solar penetration through the water and sediment deposition along the shoreline.

Manning's equation
An empirical equation used to estimate the average hydraulic conditions of flow within a channel cross section.

Manning's roughness
A coefficient (n) in Manning's equation that accounts for energy loss due to the friction between the channel and the water. Many hydraulic models use this coefficient to estimate resistance to flow.

Marsh
An area periodically inundated and treeless and often characterized by vegetation such as grasses, cattails, etc.

Mean column velocity
The average velocity of flow measured in a column extending from the surface of the water to the bed of the channel. Often referred to simply as "velocity" or "current velocity."

Meander
A stream reach that includes one complete bend, curve, or loop.

Median particle size
Value for which half the particles in a sample have a greater diameter and half a lesser diameter.

Median streamflow
The rate of discharge of a stream for which there are equal numbers of greater and lesser flow occurrences during a specified period.

Mesohabitat
Basic structural elements of a river or stream such as pools, backwaters, runs, glides, and riffles.

Microclimate
The local climate of a site or habitat.

Microhabitat
Zones of similar physical characteristics within a mesohabitat unit, differentiated by aspects such as substrate type, water velocity, and water depth that control specific locations or home ranges of aquatic organisms.

Mid-channel bar
A gravel or sand deposit formed in the middle of a stream channel, not extending completely across the channel.

Migratory corridor
Stream reaches used by fish to move between habitats.

Native
Species that occur naturally in a drainage (not introduced by humans).

Nonconsumptive use
Using water in a way that does not reduce the amount or supply. Examples include instream flows for fish and aquatic biota, hunting, fishing, boating, water-skiing, swimming, and some power production.

Non-native
Not indigenous to or naturally occurring in a given area. Presence is usually attributed to intentional or unintentional introduction by humans. Non-native species are also termed "exotic"species.

Olfactory imprinting
Process in which juvenile fish become imprinted with and are able to detect ***stream-specific odors imparted to the waters that result from watershed ch***aracteristics such as soils, flora, and fauna. Adult salmon and other fish species are able to differentiate and migrate to specific natal streams via olfaction of their specific odors.

Organics
Any woody material, such as from trees or shrubs, that washes into a stream channel or is deposited on a floodplain area. Organic debris provides important aquatic habitat functions, including nutrient sources and micro-habitats for aquatic insects and fish. Large wood is especially influential to stream morphology.

Phreatophyte(s)
Plants that send their roots into or below the capillary zone to use ground water.

PHABSIM (Physical Habitat Simulation)
PHABSIM is a set of computer programs that provides predictive relationships between flow changes and various physical and hydraulic characteristics that relate to the amounts of habitat of different fish species and life stages. The results of a PHABSIM analysis are generally reported in terms of Weighted Useable Area (WUA) versus flow. PHABSIM represents the computer programs associated with the IFIM process.

Pool
Relatively deep area in a natural stream channel with low velocity and smooth water surface as compared to other portions of the stream.

Pool tailout
Downstream end of a pool where mobile sediments deposit and the depth gradually decreases. Often an area favored by salmonids for spawning.

Productivity
A measure of the ability of an ecosystem to sustain life, including such factors as fertility, climatic conditions, and the available sunlight and water.

Q
Hydrological abbreviation for discharge, usually presented as cfs (cubic feet per second) or cms (cubic meters per second).

Quadrat
A square frame used to sample plant communities. In the high flow riparian study, the quadrat was 1 meter square.

Rating curve
A graph showing the relationship between water surface elevation and discharge of a stream or river at a given location. Also called a stage-discharge curve.

Reaeration
The exchange of gases between the atmosphere and water, a natural process counteracting oxygen depletion in a stream or lake. This process operates to maintain oxygen near the saturation concentration.

Rearing
Rearing is the term used by fish biologists that considers the period of time in which juvenile fish feed and grow. In the case of anadromous fish, the end of the juvenile rearing period culminates when the fish undergo smoltification, a process that results in physiological changes to the fish that readies it for transitioning to saltwater.

Rearing habitat
Areas in rivers or streams where fry, juvenile and adult fish find food and shelter to live and grow.

Recurrence interval
The average time, usually expressed in years, between occurrences of hydrologic events of a specified type (such as exceedance of a specified high flow or non-exceedance of a specified low flow). The term does not imply a regular cyclic occurrence. The recurrence interval for annual events is the reciprocal of the annual probability of occurrence. Thus, the 100-year flood has a 1-percent chance of being exceeded by the maximum peak flow in any year. Also known as a return period.

Refuge
An area protected from disturbance where fish or other animals can find shelter from sudden flow surges or other short-duration disturbances.

Reservoir
A body of water, either natural or artificial, that is used to manipulate flow or store water for future use.

Revetment
A facing of masonry or concrete, used to protect an embankment from erosion or slumping.

Riffle
Shallow rapids in an open stream where the water surface is broken into waves by obstructions wholly or partly submerged.

Riparian habitat
Generally, the zone of direct interaction between terrestrial and aquatic environments. With respect to the Riparian Habitat Maintenance claims, it is the vegetation adjacent to a stream that depends on water from the stream to be in a healthy condition.

Riparian zone
A stream and all the vegetation on its banks that is influenced by the presence of the stream, including surface flow, hyporheic flow and microclimate.

Riprap
Large stones or concrete placed for the purpose of protecting a slope from erosion due to flowing water.

River mile
The distance of a point on a river measured in miles from the river's mouth along the low-water channel.

Rule curve
Operational guides used in water reservoir regulation. They graphically show desired water levels and certain operating rights, entitlements, obligations, and limitations for a reservoir through the year.

Run
A section of stream characterized by deep, fast, low turbulence water.

Run-off dominated streams
Streams that are responsive to precipitation and/or snowmelt. These streams encounter much higher variability in streamflow during the year.

Sand
Substrate particles between 0.002 and 0.25 inches in size, larger than silt and smaller than gravel.

Scour
The erosive action of running water in streams, which excavates and carries away material from the bed and banks. Or, pertaining to a place on a streambed scoured by running water.

Seep
A spot where water contained in the ground oozes slowly to the surface and often forms a pool; a small spring.

Semelparous
Fish species that reproduce only once during their lifetime.

Silt
Substrate particles smaller than 0.002 inches in size.

Sinuosity
The amount of bending, winding and curving in a stream or river.

Spawning
The depositing and fertilizing of eggs by fish and other aquatic life.

Specific conductance
A measure of the ability of water to conduct an electrical current. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the dissolved solids concentration in water.

Split channel
A river having numerous islands dividing the flow into two channels. The islands and banks are usually heavily vegetated and stable. The channels tend to be narrower and deeper and the floodplain narrower than for a braided system.

Spring-dominated
Streams with a large percentage of the flow originating in springs. As a result, flows may vary only a small amount over the entire year.

Staff gage
A vertically mounted ruler that is be used to measure changes in the water surface of a river, lake or reservoir.

Stage
The elevation, or vertical distance, of the water surface above a datum.

Stage-discharge relationship
The relation between the water-surface elevation, termed stage (gage height), and the volume of water flowing in a channel per unit time.

Substrate
The material composing the streambed, including either mineral or organic matter.

Surface area
Area encompassed by the boundary of a lake or impoundment, as shown on a map or photograph, at a specific water elevation.

Terrace
A relatively level or gently inclined land surface in alluvial valleys that is elevated above an active stream channel in a step-like arrangement of a slope. Terraces are created when a stream incises and abandons its floodplain.

Terrestrial insect
Non-aquatic insects that developed from eggs laid on dry land, usually only getting into the water accidentally while they are in the adult stage of life. Examples are grasshoppers, crickets, ants, cicadas, leafhoppers, beetles, bees, and wasps.

Thalweg
The longitudinal line connecting points of lowest bed elevations along the stream course.

Thalweg depth
The vertical distance of the lowest point of a channel section to the water surface.

Thermal gradient
Temperature difference between two areas.

Thermocline
Generally, a relatively thin layer in a lake that separates an upper warmer zone (epilimnion) from a lower colder zone (hypolimnion).

Threatened
Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. These species have been given protection under the federal Endangered Species Act.

Transect
A predetermined line along which depth, velocity, or other characteristics such as canopy density are counted for monitoring purposes.

Tributary
A stream that contributes its water to another stream or body of water.

Unconfined channel
A stream that can access the floodplain when flows are greater than the normal channel dimensions.

Undercut banks
A bank that has had its base cut away by the water action along man-made and natural overhangs in the stream.

Watershed topographic
Boundary between drainage basins. Often used to describe the land area from which water drains toward a common watercourse in a natural basin.

Weighted Usable Area (WUA)
The area under the surface of a stream, weighted by its suitability, available to a life stage of an aquatic organism (see PHABSIM).

Wetted perimeter
The distance along the bottom and sides of a channel cross-section in contact with the water.

APPENDIX B

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APPENDIX C

Exhibits

281-US-401 Curriculum Vitae of Dudley W. Reiser

281-US-402 (Reiser *et. al.* 2001) Reiser, D. W., M. E. Loftus, D. Chapin, E. Jeanes, and K. Oliver. 2001. Effects of water quality and lake level on the biology and habitat of selected fish species in Upper Klamath Lake. R2 Resource Consultants, Inc. Prepared for the Bureau of Indian Affairs

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281-US-414 (Markle and Simon 1993) Markle, D. F., and D.C. Simon. 1993. Preliminary studies of systematic and juvenile ecology of Upper Klamath Lake suckers. Final Report published by Oregon State University, Corvallis. 129 p

281-US-415 Habitat Suitability Criteria (HSC) Curves for Klamath IFIM/PHABSIM Project

281-US-416 Valley Bottom Classification Upper Klamath Basin IFIM Studies

281-US-417 Field Log Book Claim Reach 668

281-US-418 ODFW Stream Habitat Summary (September 2004) – Wood River, Reach 1

281-US-419 R2 Stream Survey Report

281-US-420 Excel Spread Sheet – Data Entry Claim Reach 668

281-US-421 WUA Graphs and Flow Quantities Reach 668

281-US-422 Field Log Book Claim Reach 669

281-US-423 ODFW Stream Habitat Summary (August 2004) – Crooked Creek

281-US-424 USFS Wood River Survey

281-US-425 Excel Spread Sheet – Data Entry Claim Reach 669

281-US-426 WUA Graphs and Flow Quantities Claim Reach 669

281-US-427 Field Log Book Claim Reach 670

281-US-428 ODFW Stream Habitat Summary (September 2004) – Fort Creek

281-US-429 Fish Survey Report 1994

281-US-430 Excel Spread Sheet – Data Entry Claim Reach 670

281-US-431 WUA Graphs and Flow Quantities Claim Reach 670